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SHORT COMMUNICATION

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Behavioural response of the brown-banded water snake *Helicops angulatus* to simulated predation

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Animals display a wide array of antipredator responses, which can directly influence their survival and fitness. When confronted by a predator, an individual may use a variety of different defensive behaviours in response to relative risks, energetic demands, and intrinsic constraints (Greene, 1988; Bateman et al., 2014). To understand fully the mechanisms and factors underlying antipredator behaviour, it is essential to describe the individual behavioural sequences deployed. However, such behaviours are rarely observed in the wild, especially for elusive taxa such as snakes. Instead, simulated predation experiments can offer insights where field observations are lacking. The brown-banded water snake *Helicops angulatus* (Linnaeus, 1758) is a medium-sized, aquatic and nocturnal species that inhabits still waterbodies in forested and disturbed areas of northern South America (Bartlett & Bartlett, 2003). This snake is known to exhibit antipredator behaviour such as dorsoventral body flattening, thrashing, and striking (Martins & Oliveira, 1998). Here I describe the behavioural sequence of *H. angulatus* against simulated predation, with the first observation of balling in the species.

From 8th to 10th March 2019, I captured six juvenile and one adult *H. angulatus* by hand during the night at a pond surrounded by secondary forest in Madre de Dios, Peru (12° 53' 90" S, 71° 21' 48" W, WGS84, 498 m altitude). The snakes were brought back to a lodge where they were measured with a tape measure for snout-vent length and weighed using an electronic scale (Table 1). They were kept overnight in a plastic container with freshwater up to 5 cm deep. Then at 15:00–18:00 h on the day after capture, they were removed individually from the container and placed gently onto an indoor arena (at ambient 23–26 °C) to observe their defensive responses. Each snake was left undisturbed for 10 seconds before there was a simulated attack from an avian or mammalian predator in which the snakes were gently tapped and occasionally picked up using metal forceps for juveniles or using a snake hook for the adult (procedure modified from Mori et al., 1996). No snakes were harmed during the process. The tactile stimuli were applied for one minute, and if the snake performed balling, they were continued for another minute. Shortly after the trials were terminated, the snakes were released at their capture location. All snakes swam away with no apparent deleterious effects from the experiments.

Table 1. Body measurements and behavioural responses of *Helicops angulatus* to simulated predation. Duration of each behavioural phase is shown in parenthesis. The subsequent phase is noted after the semicolon.

Snake ID	SVL	Mass (g)	Behavioural sequence
Juveniles			
1	175	6.3	Body flattening & occasional striking (1 min)
2	185	6.6	Body flattening & occasional striking (1 min)
3	180	5.6	No reaction (12 sec); Escaping (11 sec); Body flattening (6 sec); Balling (41 sec); Body flattening
4	186	7.7	Body flattening (41 sec); Escaping
5	180	6.7	Body flattening (55 sec); Balling (> 1 min)
6	175	6.6	Body flattening & occasional thrashing (1 min)
Adult			
7	400	59.5	Occasional striking (31 sec); Balling (>1 min)

The behavioural sequences displayed by each individual are shown in Table 1. When the trials started, five of the six juvenile snakes initially displayed dorsoventral body flattening, with the body in a circular or undulating shape (Fig. 1A). Three of those juveniles, while flattening the body, occasionally made sudden strikes at the forceps with the head elevated from the ground or thrashed the body with the head touching the ground in response to the physical contact of the stimuli. Two juveniles attempted to escape by lateral undulation. The adult snake did not seem to flatten the body but struck at the snake hook. Three individuals including the adult adopted a balling posture after the initial responses had lasted for 28–55 seconds (Fig. 1B). The rather cylindrical 'ball' was made of two or three tight coils of the body, with the head positioned either on top, inside, or underneath the coils. For most of the time the long, slender tail protruded from the ball. One juvenile resumed body flattening after keeping the balling posture for 41 seconds. For the other two balling snakes, the posture persisted for more than one minute until the stimulus was terminated.

Figure 1. Antipredator responses of juvenile *Helicops angulatus* from Madre de Dios, Peru- **A.** Body flattening, **B.** Balling

Previously body flattening, striking and thrashing behaviour have been recorded as initial responses of *H. angulatus* when confronted by a terrestrial predator (Martins & Oliveira, 1998). However, during the current study balling was observed only after the tactile stimuli were continued for over 28 seconds. Balling is a behaviour displayed by various unrelated snake taxa, including boids (e.g. *Candoia aspera*, *Calabaria*, *Lichanura*, Bustard, 1969; *Eunectes*, Dirksen et al., 1998; *Tropidophis*, Hoefer et al., 2019), pythonids (*Python regius*, Schmidt & Inger, 1957), and colubrids (e.g., *Tretanorhinus variabilis*, Petzold, 1967; *Dipsas pratti*, Barros et al., 2012). The behaviour presumably functions to protect the vulnerable head (Dirksen et al., 1998). While some boids and pythonids perform balling so perfectly that the whole body forms a uniform sphere with the head completely concealed within it (Bustard, 1969), *H. angulatus* seemed to be less specialised since the 'ball' is rather cylindrical, and the head and tail remain relatively exposed. My observations suggest that balling is a last resort for both juvenile and adult *H. angulatus*, which is used only after the initial antipredator responses such as body flattening, striking, thrashing, or escaping have proved futile.

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