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Short Communication

Male-male fighting, dominance, and mating in *Epicrates assisi* (Serpentes: Boidae) in captivity

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Male-male fighting (MMF) is a ritualized behavior performed by adult snakes during the mating season (Schuett *et al.* 2001, Pizzatto *et al.* 2007). The MMF involves sequences of body interactions between two male snakes attempting to subdue one another and bring their adversary to the ground by exerting body pressures focused on the anterior portion of the body (Carpenter 1977, 1984). MMF is widespread in several lineages of snakes but it is entirely absent in others (Shine 1994, Schuett *et al.* 2001, Almeida-Santos and Marques 2002, Pizzatto *et al.* 2007). Most information about MMF is from temperate species in captivity (e.g., Schuett and Schuett 1995, Pizzatto *et al.* 2006). Despite recent advances, detailed accounts of MMF in Neotropical species are scarce (Almeida-Santos and Marques 2002, Pizzatto *et al.* 2007).

MMF is recorded among boid snakes (Osborne 1984, Schuett and Schuett 1995, Senter *et al.* 2014). In the five species of the genus *Epicrates,* MMF is known to occur in only two—viz., *E. cenchria* (Linnaeus, 1758) and *E. crassus* Cope, 1862 (Schuett and Schuett 1995, Pizzatto *et al.* 2006). We describe for the first time the sequence of events of MMF, dominance, submission, and mating in *E. assisi* Machado, 1945, a common boid snake from the Caatinga Biome in northeastern Brazil. This species is diurnal, semi-arboreal, and feeds on mammals

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and birds (Guedes *et al.* 2014, Marques *et al.* 2017).

We observed MMF in three captive specimens (2 males: 1 female) of *Epicrates assisi* maintained at the Museu Vivo Répteis da Caatinga, municipality of Puxinanã, state of Paraíba, Brazil; the snakes are known to occur in this area (Guedes *et al.* 2014). Male 1 (microchip Nº 963006008587204) was 1410 mm SVL + 166 mm TL. Male 2 (microchip Nº 96300800457500) was 1060 mm SVL + 160 mm TL. The third snake, female (microchip Nº 963006008587595) was 1141 mm SVL + 132 mm TL. The three snakes were maintained together in a masonry terrarium (3.0 × 1.90 × 1.6 m) with one wall screened, and the bottom covered by a mix of sand, soil, and leaf litter. Room temperature was ca. 20°C.

On 13 August at 23:18 h, AG observed that Male 1 was engaged in combat with Male 2. The sequence of events was directly observed and some portions were recorded using a cellphone camera. Description of MMF phases follows that of Pizzatto *et al.* (2006) and terminology follows that of Carpenter *et al.* (1976).

Phases

1) Ascent-alignment-orientation (Figure 1A).—Male 1 moves forward on the dorsum of Male 2, and both snakes simultaneously align their heads and bodies, while raising the anterior third of the body. The posterior bodies are in constant contact, one above the other or laterally. Male 1 maintains its anterior body elevated until Male 2 lowers its body to the ground.

2) Topping.—Topping with loose interweaving (Figure 1B): Both males maintain their anterior body elevated and begin entwining the posterior portion of their bodies. They keep their heads in vertical orientation (90˚). The head of Male 1 is more elevated than that of Male 2, and they continue moving forward.

Topping with firm interweaving and a third of the trunk elevated (Figure 1C): The previous phase rapidly evolves to this phase. Both males retain the anterior trunk elevated and their heads vertically oriented. The posterior part of their bodies are firmly entwining, spinning on the longitudinal axis and constricting each other vigorously. In this phase of the combat it is possible to see the males flicking their tongues. Male 1 maintains its head more elevated than Male 2.

Topping with firm interweaving and bodies on the ground (Figure 1D, E): The bodies of both males are almost entirely on the ground and are firmly entwining, spinning on the longitudinal axis and constricting each other vigorously. Male 1 used its head to maintain the other male's head pinned down on the ground.

Final Topping (Figure 1F): The males attempt to elevate their anterior bodies while remaining fully intertwined. They are unable to maintain the upright position and fall to the ground, causing their bodies to separate. After they fall, they quickly return to the upright position and the whole sequence of topping is repeated numerous times. During this phase, Male 1 always maintains its head above the head of Male 2.

3) Dominance.—Both males remain close to each other, but do not interweave. Male 1 keeps its head in vertical position, dominating Male 2. Male 2 shows no interest in continuing the combat. The combat ended at 23:25 h and was 8 min long.

The males were observed for the next 2 h, but they did not engage in further combat. It is unknown if combat continued later in the night. During the entire sequence, the female remained coiled on the ground in a corner of the terrarium, seemingly inactive (Figure 1G). On the following morning, 14 August, from 08:00– 11:17 h, Male 1 was observed copulating with the female (Figure 1H). Male 2 remained curled up at the opposite side of the terrarium and was motionless the entire day. One week later, on 21 August at 17:10 h, Male 1 was seen courting the female again in the water container, but they did not

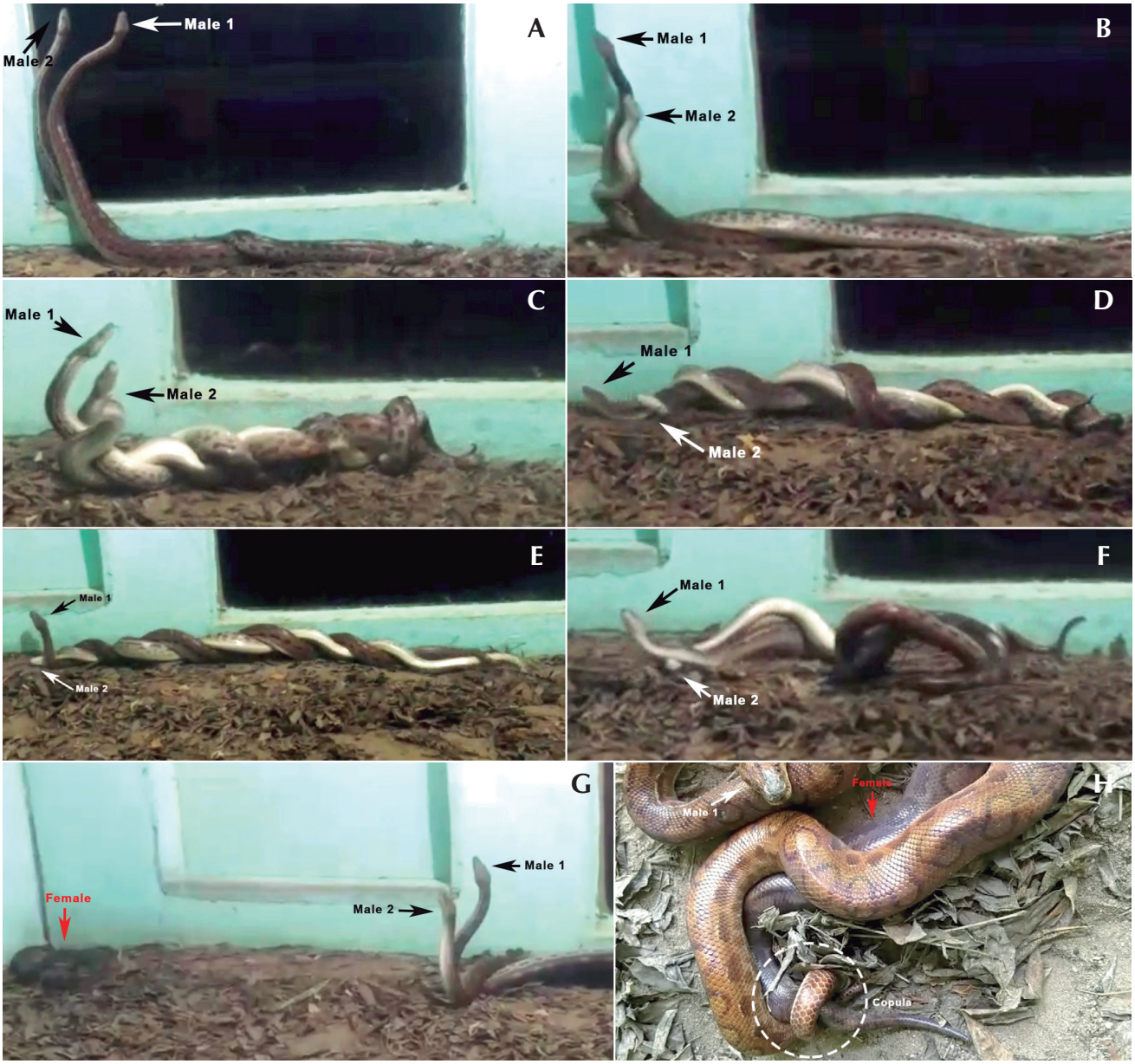

Figure 1. Male-male fighting sequence in *Epicrates assisi*. (**A**) *Ascent-alignment-orientation* phase in which Male 1 advances over the dorsum of Male 2, showing hyperextension dorsally which produces high vertical stance and neck flexion. (**B**) *Topping with loose interweaving* in which both males maintain the anterior third of the trunk vertical and begin entwining the posterior part of the body. (**C**) *Topping with firm interweaving and the anterior third of the trunk elevated* in which the posterior part of their bodies are firmly entwining, spinning on the longitudinal axis, and constricting each other vigorously. It is possible to see the males flicking their tongues during combat. (**D, E**) *Topping with firm interweaving and the entire body on the ground* in which both males keep their bodies entirely on the ground firmly entwining, spinning on the longitudinal axis and constricting each other vigorously. (**F**) *Final Topping* in which the snakes cannot maintain the upright position and tumble; note that Male 1 is positioned over Male 2 and its head is more elevated. (**G**) During the ritualized combat, the female was coiled up on the ground in a corner of the terrarium and seems inactive; the head of Male 1 is held above the head of Male 2. (**H**) Male 1, which won the combat, was observed copulating with the female in the morning following the MMF.

copulate; in the meantime, Male 2 remained curled up in the corner of the terrarium. On 25 August at 18:00 h, Male 1 was removed from the terrarium and subsequently Male 2 was seen courting the female at 18:32 h, but it is not known whether copulation occurred.

Some phases the MMF of *Epicrates assisi* resemble those described for other species of snakes, including some boids (Shine 1994, Schuett and Schuett 1995, Almeida-Santos *et al.* 1998, Almeida-Santos and Marques 2002, Pizzatto *et al.* 2006, 2007, Senter *et al.* 2014). In some species of *Epicrates,* males engage in combat attacks (Schuett and Schuett 1995, Tolson 1992, Pizzatto and Marques 2007), even when males and females did not differ significantly in mean body size as observed by Pizzato and Marques (2007), which contradicts Shine's prediction (1994). However, our data show that Male1 was ~ 25–30% longer than the female.

Pizzatto *et al.* (2006) described a "Recognition-investigation phase" just before the combat between males of *Epicrates crassus.* We did not observe this phase for *E. assisi,* possibly because the two males had shared the same terrarium for almost a year and this phase was not necessary, whereas in the case described by Pizzatto *et al.* (2006) the males were introduced for the first time and immediately began combat.

Combat in *Epicrates assisi* consists of high vertical position of the head and neck. This can occur with the head inclined posteriorly (hyperextension dorsally, according to Carpenter *et al.* 1976) while the snakes intertwine. We observed four distinct steps of the topping phase in *E. assisi* that are sequentially repeated until dominance is established. These results differ from those reported by Pizzatto *et al.* (2006), who could not distinguish an oriented sequence of behaviors while describing the topping phase of *E. cenchria.* As observed by Pizzatto *et al.* (2006), we did not record any bite during the MMF. The "Spur Poke" behavior (Senter *et al.* 2014) was not obvious in *E. assisi* but could have occurred quickly while during tail-to-tail contact between the two males.

All MMF events previously recorded in *Epicrates* (e.g., Schuett and Schuett 1995; Pizzatto *et al.* 2006, this study) are associated with the breeding period (Tolson 1992), which usually occurs from autumn to winter (Schuett and Schuett 1995, Pizzatto *et al.* 2006). In *E. crassus,* ritual combat was observed during the autumn (Pizzatto *et al.* 2006), the same period when the elevated level of testosterone was related to agonistic behavior in males of *E. striatus* (Fischer, 1856). In *E. striatus,* larger males have higher testosterone levels, and are frequently dominant in MMF (Teubner; in Tolson 1992). In *E. assisi,* the season of the combat coincides with increased volume of the testis, which reflects testicular activity during the winter (Pizzatto and Marques 2007). Female *E. assisi* are in vitellogenesis from May–August, during the autumn. Therefore, we can associate the MMF and mating season of *E. assisi* in the Caatinga to the period of low temperature and the dry season (Figure 3 in Marques *et al.* 2017).

In this study, Male 1 was ca. 23% larger than Male 2. This difference seemed enough to render Male 1 the winner of the fight to court and copulate with the female in the enclosure. If similar to *E. striatus,* hormone levels in the larger Male 1 should be higher, resulting in its dominance. Our observations of males flicking the tongue during the topping phase, indicate that chemical cues play an important role in MMF in *E. assisi.*

The combat occurred in the presence of the female, which was in the same terrarium. Soon after establishing dominance, Male 1 actively courted the female, while Male 2 exhibited post-combat submission behavior for several days. However, after removal of the dominant male, Male 2 was observed courting with the female, suggesting a polyandric mating system may occur (Rivas and Burghardt 2005).

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