

Constricting defensive behaviour of the Salmon-bellied Racer, *Mastigodryas melanolomus* (Cope, 1868), against raptor predation in Costa Rica

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Predator-prey ecological interactions are important forces shaping evolutionary processes (Abrams, 2000). Among vertebrates, snakes are prey to many organisms (Guthrie, 1932; Greene, 1988) and represent a model to understand the evolution of antipredator defences (Schalk and Cove, 2018). Snakes are important prey to raptorial birds, and for some raptor species snakes represent the main prey item. For example, the Laughing Falcon (*Herpetotheres cachinnans*) mainly feeds on snakes (Costa et al., 2014), including venomous coralsnakes (DuVal et al., 2006). Another example is the Short-toed Snake Eagle (*Circaetus gallicus*), whose diet consists to 80% of snakes (Bakaloudis et al., 1998).

Snakes have evolved diverse morphological, chemical, or behavioural antipredator mechanisms to scare potential predators or escape from them (Greene, 1988). Constriction of prey is a behavioural mechanism considered a key innovation in the evolution of snakes (Greene and Burghardt, 1978). However, constriction can also function as a defensive response when snakes are attacked by predators. Constricting defensive behaviour seems to be effective against predatory snakes (Paden et al., 2019) and small mammals (Shedd et al., 2021), but mostly against raptorial birds, specifically hawks and owls (Laverde-R. and Pinzón, 2025). Constricting raptors as a defensive mechanism has been reported in several snake species (Table 1).

Additionally, several instances of this constricting defensive behaviour have been uploaded as videos to YouTube or posted on Reddit and Instagram (see Laverde-R. and Pinzón, 2025). These snake-raptor interactions can result in the death of both individuals (Van Heest and Hay, 2000; Perry et al. 2001), or death of the snake or raptor (Vandermaast, 1999), or the survival of both (Wenner, 2012; Laverde-R. and Pinzón, 2025).

In 2013, we described a novel constricting defensive behaviour of the Salmon-bellied Racer (*Mastigodryas melanolomus*) against its potential predator, the Roadside Hawk (*Rupornis magnirostris*, total length up to 38 cm, weight 290 g; Stiles and Skutch, 2007) in southern Costa Rica (Oviedo-Brenes et al., 2013). Here we describe two new observations of this defensive strategy by *M. melanolomus*, involving a different and larger raptor species, at two different locations in Costa Rica. This snake species (maximum total length 140 cm) ranges from Mexico to Colombia, at elevations from sea level to 1750 m. It is common, frequently seen, diurnal, and feeds on lizards, frogs, birds, and small mammals (Leenders, 2019). The Broad-winged Hawk (*Buteo platypterus*, total length up to 43 cm, weight 450 g; Stiles and Skutch, 2007) is distributed from Canada to Argentina (Goodrich et al., 2020). In Costa Rica, it is a common and widespread winter resident from September to May, occurring at elevations from sea level to 2000 m (Stiles and Skutch, 2007; Garrigues and Dean, 2014). It is a generalized predator that feeds on insects, amphibians, snakes, birds, and mammals. It prefers to forage in open areas, forest openings, and edges, usually perching in tree limbs, utility poles, and wires (Stiles and Skutch, 2007; Goodrich et al., 2020).

On 23 January 2023 at 16:30 h, we observed an adult *M. melanolomus* strangling an adult Broad-winged Hawk (Fig. 1A–E) in Los Altos de San Luis, Monteverde, Puntarenas, Costa Rica (10.2836°N, 84.7936°W). The entwined snake and hawk were found in the middle of a dirt road. The snake coiled around the base of both wings,

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Table 1. Constricting defensive behaviour of snakes against raptors reported in the literature.

Snake Species	Raptor Species	Reference
<i>Charina bottae</i> (Blainville, 1835)	Red-tailed Hawk (<i>Buteo jamaicensis</i>)	Van Heest and Hay, 2000
<i>Coluber constrictor priapus</i> Dunn & Wood, 1939	Great Horned Owl (<i>Bubo virginianus</i>)	Perry et al., 2001
<i>Dendrophidion dendrophis</i> (Schlegel, 1837)	Roadside Hawk (<i>Rupornis magnirostris</i>)	Laverde-R. and Pinzón, 2025
<i>Drymarchon melanurus</i> (Duméril et al., 1854)	Roadside Hawk (<i>Rupornis magnirostris</i>)	Laverde-R. and Pinzón, 2025
<i>Elaphe quatuorlineata</i> (Lacépède, 1789)	Common Buzzard (<i>Buteo buteo</i>)	Aloise et al., 2010
<i>Leptophis depressirostris</i> (Cope, 1861)	White Hawk (<i>Pseudastur albicollis</i>)	Laverde-R. and Pinzón, 2025
<i>Mastigodryas melanolomus</i> (Cope, 1868)	Roadside Hawk (<i>Rupornis magnirostris</i>)	Oviedo-Brenes et al., 2013
<i>Mastigodryas pleii</i> (Duméril et al., 1854)	Roadside Hawk (<i>Rupornis magnirostris</i>)	Laverde-R. and Pinzón, 2025
<i>Masticophis flagellum</i> (Shaw, 1802)	Red-shouldered Hawk (<i>Buteo lineatus</i>)	Perry et al., 2001
<i>Masticophis flagellum</i>	Great Horned Owl (<i>Bubo virginianus</i>)	Peterson, 1968
<i>Pantherophis obsoletus</i> (Say, 1823)	Red-shouldered Hawk (<i>Buteo lineatus</i>)	Williams, 1951
<i>Pantherophis obsoletus</i>	Red-shouldered Hawk (<i>Buteo lineatus</i>)	Meshaka et al., 1988
<i>Pantherophis obsoletus</i>	Red-tailed Hawk (<i>Buteo jamaicensis</i>)	Vandermaast, 1999
<i>Philothamnus irregularis</i> (Leach, 1819)	Lizard Buzzard (<i>Kaupifalco monogrammicus</i>)	Athias, 1972
<i>Pituophis catenifer</i> (Blainville, 1835)	Red-tailed Hawk (<i>Buteo jamaicensis</i>)	Wenner, 2012
<i>Zamenis longissimus</i> (Laurenti, 1768)	Common Buzzard (<i>Buteo buteo</i>)	Happ, 2017

completely immobilizing the hawk. The hawk attempted to escape with a short jump but failed, and the unsuccessful escape attempt resulted in the hawk landing at the side of the road. The hawk appeared exhausted and seemed to struggle with breathing, although we did not observe any major external injuries. The snake showed no signs of fatigue or injury and appeared well-defended against the hawk. Both individuals remained entangled for at least 1.5 h. We were unable to observe the conclusion of this interaction but consider the survival of both animals likely. When we checked the site again at 18:00 h, there were no signs of the snake or the hawk. On 6 March 2023 at 15:00 h a second observation of an adult *M. melanolomus* strangling an adult Broad-winged Hawk was photographed in San Ramón, Alajuela, Costa Rica (10.1386°N, 84.5647°W; Fig. 1F). Unfortunately, no additional information is available for this second observation.

The defensive repertoire for snakes in the genus *Mastigodryas* includes escape, body thrashing, cloacal discharge, tail vibration, pseudoautotomy, and striking and biting. These behaviours have been documented in *M. melanolomus* (Delaney, 2019; Nolasco-Luna et al., 2019) and Boddaert's Tropical Racer, *M. boddaerti* (Martins and Oliveira, 1998; Roberto, 2011). Pseudoautotomy has also been reported in the Heath's Tropical Racer, *M. heathii* (Cadle, 2012), as well as in the Rio Tropical Racer, *Palusophis bifossatus* (reported as *Mastigodryas bifossatus*; Ferreira and Outeiral, 1998; Leite et al., 2009; Dourado et al., 2013). A more unusual defensive behaviour has been described in *M. pleii*, which climbs into the spiniest parts of cacti to avoid predators (Mijares-

Urrutia and Cieza-Unefm, 1992). This snake also exhibits constricting defensive behaviour against hawks (Laverde-R. and Pinzón, 2025), as does *M. melanolomus* (Oviedo-Brenes et al., 2013; this study).

Birds represent significant selective pressures shaping the evolution of antipredator defences in reptiles (Greene, 1988). The constricting defensive behaviour reported here offers valuable insights into the evolution of such mechanisms and raises several important research questions. For example, how many other snake species exhibit this behaviour, and is it more prevalent among diurnal species that are primarily preyed upon by raptors? Furthermore, are species that constrict their prey more likely to evolve this form of defence? Snake species with larger body size seem to have a more diverse repertoire of defences and higher levels of aggressiveness (Delaney, 2019). Therefore, is the constricting defensive behaviour influenced by body size, age and experience? Additionally, snakes detect predators using visual, thermal, auditory, and/or tactile cues (Greene, 1988), and responses to sound vary across genera (Zdenek et al., 2023). Because effective defence depends on accurate predator detection, this prompts an additional question: which sensory cues do snakes that exhibit this defensive behaviour rely on to perceive approaching predators?

Observing predator-prey interactions between snakes and raptors is challenging, and such encounters are rarely witnessed or documented. These two new records of strangling defensive behaviour by *M. melanolomus* suggest that this is a well-established defensive strategy against raptor predation, as previously shown

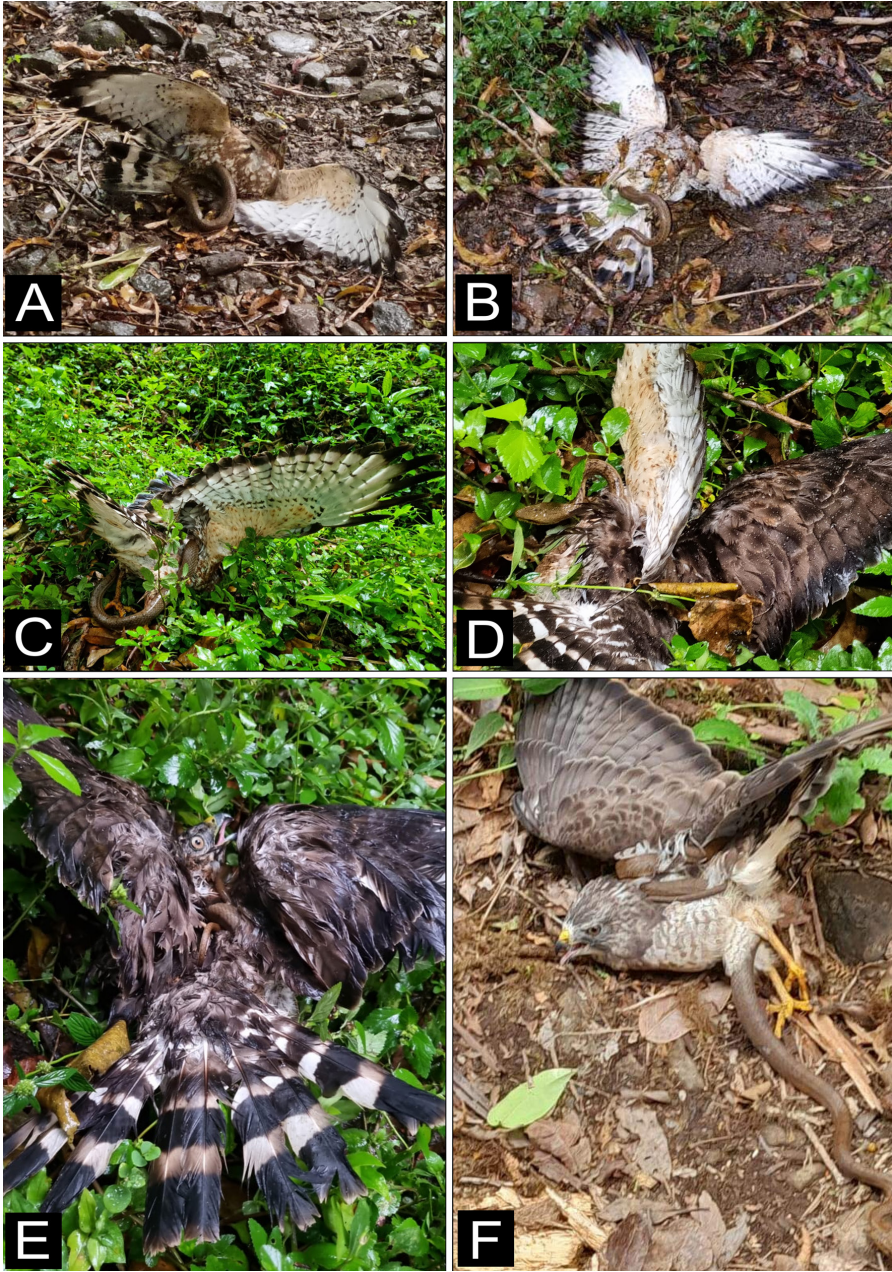


Figure 1. Two instances of Salmon-bellied Racers (*Mastigodryas melanolomus*) constricting Broad-winged Hawks (*Buteo platypterus*) as a defence behaviour in Costa Rica. The observations in (A–E) are from Los Altos de San Luis, Monteverde, Puntarenas (photos by Daniel Leitón), and (F) is from San Ramón, Alajuela (photo by Philip Kay). In both cases, the snake constricted the bird using the posterior portion of its body, keeping the head away from the reach of the hawks' beak. (A) Snake and hawk were found in the middle of a dirt road. (B) The snake is immobilizing the hawk by wrapping its body around the hawk's body and the base of its wings. This activity led to the hawk getting flipped onto its back. The head of the snake is moving freely near the hawk's tail feathers. (C) The hawk managed to lift up briefly in an unsuccessful escape attempt but landed in adjacent roadside vegetation. (D) The hawk is immobilized at the side of the road, with the snake's head seen close to the hawk's head in the centre-left of the image. (E) The hawk is gasping and dishevelled, showing signs of exhaustion after being constricted by the snake for several minutes. (F) This snake has immobilized the hawk by constricting around the base of the wings. The snake's head is at lower right in the image, far from the hawk's head.

by (Oviedo-Brenes et al., 2013). This behaviour may represent an important defensive mechanism to avoid predation by aerial predators when escape is not possible (Delaney, 2019). We believe this defensive behaviour is underreported and may also occur in other snake species. Natural history observations are fundamental to understanding the ecology and evolution of organisms, and for strengthening connections with, and protection of, biodiversity (Ricklefs, 2012; Powers, 2025).

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