REPTILES & AMPHIBIANS

Caudal Pseudoautotomy in Three Sri Lankan Species of Snakes (Natricidae and Viperidae)

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Self-amputation of expendable body parts as a defensive strategy has evolved multiple times independently in the animal kingdom, and has been observed among both vertebrates (mammals, salamanders, non-serpentine lizards) and invertebrates (echinoderms and crustaceans) (Clause and Capaldi 2006). However, caudal autotomy, the ability to voluntarily detach the tail in response to an encounter with a predator has been frequently observed among salamanders and lizards (Pough et al. 2016). Its frequent expression across multiple herpetofaunal taxa suggests that caudal autotomy is a successful behavioral response that substantially elevates the survival rate of potential prey (Clause and Capaldi 2006). Among lizards, this behavior has been observed in 13 of 20 lizard families (Downes and Shine 2001) and its evolutionary history is traceable to Early-Permian captorhinids. By detaching the tail from the body, lizards can escape a predator's grasp while the severed tail continues to spontaneously and vigorously writhe, attracting the predator's attention away from the lizard (Edmunds 1974; Bateman and Fleming 2009).

However, caudal pseudoautotomy, intervertebral tail detachment in response to mechanical resistance without tail regeneration, is infrequently observed among snakes (Ananjeva and Orlov 1994; Dutta et al. 2022), with this behavior mostly documented among African colubrids (Broadley 1987; Akani et al. 2002). Thus far, caudal pseudoautotomy has been recorded in only a few snake genera (*Amphiesma*, *Coluber*, *Coniophanes*, *Dendrophidion*, *Drymobius*, *Enulius*, *Fowlea*, *Natriciteres*, *Nerodia*, *Pliocercus*, *Psammophis*, *Rhabdophis*, *Rhadinaea*, *Scaphiodontophis*, *Sibynophis*, *Thamnophis*, *Vipera*, and *Xenochrophis*) (Duellman 1979; Sharma 1980; Broadley 1987; King 1987; Mendelson 1991; Ananjeva and Orlov 1994; Todd and Wasserzug 2010; Hoogmoed and Avila-Pires 2011; Strugariu et al. 2018; Dutta et al. 2022). Caudal pseudoautotomy remains understudied in Sri Lanka (De Silva 1980).

We observed four instances of caudal pseudoautotomy in three Sri Lankan species of snakes. The first two cases were observed in Tikiri Keelbacks (*Fowlea unicolor*) (Natricidae),

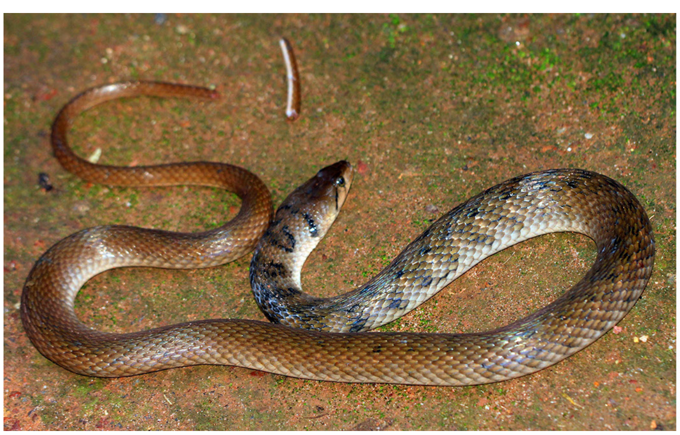

Figure 1. A Tikiri Keelback (*Fowlea unicolor*) with a broken tail in Anuragoda, Kiridiwela, Gampaha District, Sri Lanka. Photograph by Suranjan Karunarathna.

Figure 2. The broken tailpiece of a Sri Lankan Keelback (*Fowlea asperrima*) in Nawalapitiya, Kandy District, Sri Lanka. Photograph by Dushantha Kandambi.

Reptiles & Amphibians ISSN 2332-4961
https://doi.org/10.17161/randa.v30i1.20655

were observed at 1430 h in August 2018 at Dediyawala, Waskaduwa, Kalutara District (elev. 4 m) and at 1610 h in January 2021 at Anuragoda, Kiridiwela, Gampaha District (elev. 28 m; Fig. 1). Both were in a southwestern lowland wet zone of Sri Lanka. The lengths of both snakes were ~60 cm. The third observation, of a Sri Lankan Keelback (*Fowlea asperrimus*) (Natricidae) (~90 cm) that self-amputated its tail, occurred at 1450 h in May 2014 at Rambukpitiya, Nawalapitiya, Kandy District (elev. 827 m), at lower elevations in the Central Highlands of Sri Lanka (Fig. 2). The final observation, in a Russell's Viper (*Daboia russelii*) (Viperidae) (~120 cm), was at 1540 h in June 2015, at Bollatha, Ganemulla, Gampaha District (elev. 29 m), in a southwestern lowland wet zone.

All of the snakes were adult males, had a third of the tail length severed, and attempted to escape after caudal pseudoautotomy. All observations were in the evening in a southwestern wet zone. These are the first documented cases of caudal pseudoautotomy in *Fowlea asperrimus* and *Daboia russelii*. All occurred when we attempted to manually capture and handle the snakes by their tails. We were careful not to apply excessive force on the tail when handling the snake, therefore direct injury as the proximal cause of tail breakage can be ruled out, particularly since the tails of all four snakes broke on first contact. Partial and complete tail detachment during capture attempts has been noted in Eastern Ribbonsnakes (*Thamnophis saurita*) in Nova Scotia, Canada (Todd and Wassersug 2010). However, ribbonsnakes do not detach tails unless they are forcefully gripped by the tail alone, at which point the snake will rotate along its longitudinal axis. This contrasts with our observations, during which autotomy occurred immediately without forceful gripping. None of these snakes displayed other defensive behaviors such as striking or convoluting. Although caudal pseudoautotomy increases the immediate chance of survival, it is not without costs. Tail loss can divert limited resources to tail regeneration, thereby reducing growth rates, hindering foraging abilities, lowering reproductive fitness and locomotor performance, resulting in behavioral abnormalities and diminished social status (Downes and Shine 2001). However, compensatory locomotor performance has been observed among tail-autotomized wall lizards (Brown et al. 1995).

While caudal autotomy via intravertebral fracturing is characteristic of most non-serpentine squamates, intervertebral fracturing is the norm among tail-autotomizing snakes (Ananjeva and Orlov 1994). Nonetheless, several morphological traits, such as long and relatively thick tails, increased number of vertebrae, and short hemipenes, have coevolved with caudal pseudoautotomy in snakes (Ananjeva and Orlov 1994; Slowinski and Savage 1995), although pseudoautotomy also has been noted in snakes with fragile tails (Todd and Wassersug 2010).

Unlike in other squamates, tail loss in snakes is permanent and likely involves a central neurological control (Bateman and Fleming 2009), which likely is the case for the species we observed. Snakes also are known to use their tails for other forms of communication, such as misdirecting a predator attack, warning, aposematism, locomotion, and prehensile functions (Greene 1973). However, we are unaware of any unique, species-specific tail functions among the snake species we observed in this study. This caudal pseudoautotomy could be coincidental, perhaps an adaptation to evade predatory mammals and wading birds. Assessing the long-term costs of non-regenerative caudal pseudoautotomy in snakes will require further research.

Acknowledgements

We thank Madhava Botejue, Niranjan Karunarathna, and Dinesh Gabadage for assistance in the field, and the Department of Wildlife Conservation and the Forest Department for issuing research permits to study reptiles in Sri Lanka.

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