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Short Communication

A Yellow-headed Gecko *Gonatodes albogularis* (Duméril and Bibron, 1836) with Bifurcated Tail in the Caribbean Lowlands of Costa Rica

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Abstract: Autotomy is an escape mechanism in lizards, follow by subsequent tail regeneration. Tail loss initiates a spontaneous epimorphic regenerative program, resulting in a fully functional replacement. Sometimes there are complications and the result is a bifurcated tail that can have negative consequences for the lizard. On 27 July 2019 at about 1000 h we found an adult male yellow-headed gecko with a bifurcated tail at Gandoca-Manzanillo Wildlife Refuge, Limón, Costa Rica. The last portion of its right side tail had a small rod apparently regenerated, but its seems difficult to determine if any of the bifurcated tails is product of regeneration. An individual without the white tip of the tail could have more difficulties to show up and defend its territory. We discuss this case based on similar cases found elsewhere.

Key words: appendage loss, autotomy, regeneration, reptiles, Spherodactylidae.

Introduction

Appendage regeneration in reptiles is usually restricted to the replacement of the tail, basically in lizards that can self-amputate the tail as a defensive behavior (Clause and Capaldi, 2006; Cortada, *et al*., 2017). In fact, autotomy is one of the most spectacular escape mechanisms in lizards, follow by subsequent regeneration (Pianka and Vitt, 2003). In response to a predatory presence or attack, the lizard voluntarily detached the tail at a specific fracture plane in vertebrae (Pelegrin and Muniz Leão, 2016). The lizard releases its tail by means of powerful muscle contractions (Vitt and Caldwell, 2014), and it immediately begin to thrash violently supported metabolically by anaerobic respiration, and it continues to thrash for extended time periods (Pianka and Vitt, 2003). The shed tail distracts the predator from any further attack and provide the individual with time to flee to safety (Arnold, 1988), leaving it holding a thrashing and expendable body part (Vitt and Caldwell, 2014). However, one of the most important steps following a successful autotomous escape is the regeneration of the tail (Clause and Capaldi, 2006). Tail loss initiates a spontaneous epimorphic regenerative program, resulting in a fully functional, although structurally non-identical replacement (Gilbert, *et al.,* 2013). Regenerated tails can be smaller, similar to, or larger than original tails (Vitt and Caldwell, 2014). Caudal autotomy is a mechanism that has been reported for 13 lizard families, although it can be absent in certain species (Bateman and Fleming, 2009).

Generally, the new tail replaces the autotomized tail, although sometimes there are complications (Hoefer and Robinson, 2020). There are many reports of bifurcated tails in lizards, with some recent reports by García-Vinalay (2017); Kolenda, *et al.,* (2017); Koleska, *et al.,* (2017); Maria and Al-Razi (2018); Ramadanović and Zimić (2019); Arango-Lozano and Patiño-Siro (2020); and Hoefer and Robinson (2020). There are even occasional cases of trifurcation or

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more (Hoefer and Robinson, 2020). Tail bifurcation is considered to be a frequent malformation among lizards and is recorded in several families (Koleska *et al*., 2017). Tails are useful for prehensility, counter balance, and distract predators (Pianka and Vitt, 2003). As a result, malformed tails could have negative consequences.

One of the groups of lizards with high capacity for autotomy are the geckos (Pianka and Vitt, 2003). The infraorder Gekkota includes Sphaerodactylidae, a highly diversified family with some 216 diurnal species (Leenders, 2019). There are six species of Sphaerodactylidae in Costa Rica (Leenders, 2019). Savage (2002) pointed out that these geckos are very small and difficult to distinguish between them, except the yellow-headed gecko *Gonatodes albogularis* (Duméril and Bibron, 1836). This is a diurnal and arboreal species with bright orange head, blackish to gray brown bodies with bluish lateral spots, a conspicuous blue line on the white supralabials, and a white tail tip (Savage, 2002). This gecko measures up to 113 mm total length with no sexual dimorphism in size; the moderate tail represents 50 to 58% of total length (Savage, 2002).

Yellow-headed gecko is a common lowland lizard found from southern Mexico and Central America to northern South America, from 2 up to 1,000 m elevation (Leenders, 2019). It was introduced to Florida and also occurs on adjacent islands of Colombia and western Venezuela, and Cuba, Jamaica, Grand Cayman, and Hispaniola (Savage, 2002). This lizard is often seen on palms, strangler figs, or other trees with deeply creviced bark (Leenders, 2019), but also in pastures, roadside fences, fallen logs, trash piles, and human-made structures (Savage, 2002).

Materials and methods

During a field trip to the Caribbean lowlands of Costa Rica we visited the Gandoca-Manzanillo Wildlife Refuge, Manzanillo sector in the Limón province on 26-28 July 2019. This refuge was created in 1985 and it encompasses both marine areas (4,436 ha) and coastal terrestrial areas (5,013 ha) with several residential areas designated for conservation in Talamanca County (Boza, 1988). Forest of Gandoca-Manzanillo is classified as a humid tropical rainforest, but the refuge encompasses several rare habitats like a lowland rainforest, a wetland of 400 ha with dense forest of Orey (*Campnosperma panamensis*) and Yolillo (*Raphia taedigera*), a mangrove swamp (mainly *Rhizophora mangle*), an area of 300 ha of Cativo (*Prioria copaifera*), a precious wood, and coral reefs (Boza, 1988). We walked the main trail of the refuge in the morning, afternoon and night on 27 July searching for amphibians and reptiles. We photographed every individual spotted without any other disturb and continued the hike.

Results

On 27 July 2019 at about 1000 h we found an adult male yellow-headed gecko with a bifurcated tail. The last portion of its right side tail had a small rod apparently regenerated, but its seems difficult to determine if any of the bifurcated tails is product of regeneration (Figure 1). However, the white final section of the tail is not well defined, the tip of the tail is not markedly white as in normal-tailed individuals. This gecko was at the base of the trunk of a big beach almond (*Terminalia catappa*) on the trail near the entrance of the refuge (9°38’15″N, 82°39’02″W). This introduced tree species is highly abundant in this area of the refuge. Yellow-headed gecko is very common in the area, and usually individuals are observed moving in low vegetation, especially on the trunks of large trees. We found 16 adult yellow-headed geckos (9 males and 7 females) that morning from the entrance of the refuge to the outlook point, a transect of about 500 m long and 10 m wide. None of all other observed individuals exhibited tail anomalies.

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Figure 1. A yellow-headed gecko (*Gonatodes albogularis*) with a bifurcated tail, note the regenerated section of the right tail. Gandoca-Manzanillo Wildlife Refuge, Limón, Costa Rica. Photo by José M. Mora

Discussion

Autotomy in the form of tail shedding is one of the most remarkable features of many lizards (Gordeev, *et al.,* 2020). Moreover, many species are able to regenerate the tail after self-amputation (Cortada *et al*., 2017). However, sometimes the new tail is malformed and this could have some negative consequences for the lizard. Loss of tails by lizards has potential energetic, social, and survival costs, and some individuals could suffer reduced social status, reduced mating success, and long term effects including reduced home range size and reduced access to females (Vitt and Caldwell, 2014). Sometimes the tail breaks but it still attached to the body, leading to a regenerated tail with two or even more tips (Pheasey, *et al.,* 2014). Tail bifurcation has been reported for many lizard families including geckos of Sphaerodactylidae (Montes-Gavilán, *et al.*, 2018). Tail malformations in lizards, such as supernumerary tails, are usually associated with regeneration failures, a result of a previous injury as opposed to congenital malformations (Conzendey, *et al.*, 2013; Koleska *et al*., 2017). An individual with multiple tails could reduce its fitness because the tail plays an important role in locomotion and can affect such activities as foraging, mating, and the ability to escape from predators (Passos, *et al.,* 2014).

Yellow-headed gecko occurs in greatest densities throughout the lowlands of its distribution range (Fitch, 1973 a). Adult males are territorial and chase smaller males away from a defended area, and spacing by an aggressive display in which they lower the tail directly forward over the back and wave it up and down in a jerky motion that emphasizes the white tail tip (Fitch, 1973 b). They also raise the body, lower the head, and twitch the head laterally. If these behaviors do not discourage an intruding male, the resident male may rush toward the opponent,

striking him and trying to bite him (Savage, 2002). An individual without the white tip of the tail could have more difficulties to show up and defend its territory. Males with abnormal tails would have to go directly to chase and even bite other males because they have to skip the showing of the white tip of the tail as part of the territorial behavior sequence. Large trees such as figs (*Ficus* spp.) often have sizable colonies of ten to thirty or forty individual yellow-headed geckos (Fitch, 1973 a). As a result, the competence for space and other resources should be high, and a gecko with a bifurcated tail could be in disadvantage.

Tail loss costs have been evaluated in lizards regarding regrowth of single tails, however, no studies are available in literature about the costs of abnormal tail regeneration (Pelegrin and Muniz Leão, 2016). As a result, potential negative effects of multiple tails in lizards still remain unknown (Hoefer and Robinson, 2020). Also, despite being widespread, knowledge on frequency of tail bifurcation is still scarce (Kolenda, *et al.,* 2017).

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