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First record of tail bifurcation in the wall lizards *Darevskia caspica* Ahmadzadeh et al., 2013 and *D. chlorogaster* (Boulenger, 1908) from northern Iran

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Many lizards have a unique structure in their tail vertebrae that allows breakage, usually without losing blood (Zani, 1996; Bateman and Fleming, 2009; Alibardi, 2010). Lizard tail autotomy is primarily a way to escape from predators (Vitt and Caldwell, 2013) but can also result from intraspecific aggression, mating, or territorial combat (Koleska et al., 2017). In response, individuals detach their tails voluntarily at a particular fracture plane in the vertebrae. After losing the tail, the regeneration process begins, and a new tail starts to grow (Vitt and Caldwell, 2013). When autotomy is incomplete, as can occur in some cases, the newly regenerating tail may have more than one tip (Tamar et al., 2013). Incomplete caudal autotomy requires sufficient damage to activate the tail regeneration mechanism to cause this bifurcation (Dudek and Ekner-Grzyb, 2014). During the regeneration process, vertebrae do not regenerate in the new tail and are replaced by a cartilaginous rod (Alibardi, 2010).

Ecologically, tail autotomy can have benefits and costs. While it is clearly a predator-avoidance behaviour, it may have negatively impact intraspecific signalling, courtship, and mating, movement patterns, and habitat usage (Fox et al., 1990; Martín and Salvador, 1992; Martin and Avery, 1998; Bateman and Fleming, 2009; McElroy and Bergmann, 2013; Jagnandan et al., 2014). In addition, the tail is essential to store fat and nutrients for energy (Dial and Fitzpatrick, 1981). Individuals without tails or with deformed tails may lose reproductive fitness and social status because they may be less competitive and sexually unappealing (Martin and Salvador, 1993; Maginnis, 2006).

The lacertid genus *Darevskia* Arribas, 1999 currently comprises 35 species of lizards, distributed in a broad range of habitats of southeastern Europe and western Asia, including forest, meadows, and rocky habitats (Ahmadzadeh et al., 2013; Midtgaard, 2019). Ten species of *Darevskia* occur in Iran, and we here report tail bifurcation in *D. chlorogaster* and *D. caspica* from the southern coast of the Caspian Sea in northern Iran. *Darevskia chlorogaster* is distributed from southeastern Azerbaijan to northwestern Iran in Gilan Province, in the western part of the Hyrcanian forest from sea level to 1500 m. *Darevskia caspica* is restricted to the central part of the Hyrcanian forest in Mazandaran Province and lives at lower elevations.

During a survey of herpetological fauna in the western and central parts of the Hyrcanian forests in Gilan and Mazandaran Provinces from 10–12 September 2016, we recorded and captured individuals of these two species with bifurcated tails. The first observation was an adult female *D. chlorogaster* (Fig. 1A) in Bandar-e Anzali, Gilan Province, Iran (37.4500°N, 49.4833°E; elevation 26 m). Head length (HL) and snout–vent length (SVL) were 13.1 mm and 56.4 mm, respectively. The original and longer tail measured 61.8 mm, while the shorter and regenerated tail was 46.9 mm long. The second observation was an adult male *D. caspica* (Fig. 1B) in Zarrin Abad, Mazandaran Province (36.5166°N, 53.1833°E; elevation 50 m). This individual had an HL of 18.2 mm and an SVL of 58.12 mm. The original and longer tail measured 94.2 mm, while the shorter and regenerated tail was 78.3 mm long. Despite this malformation, both observed individuals seemed to be in a good nutritional state without any other visible deformities or injuries. These are the first records of tail

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Figure 1. Bifurcated tails in (A) *Darevskia chlorogaster* and (B) *D. caspica* from Gilan and Mazandaran Provinces, Iran. Photos by Reza Babaei Savasari.

bifurcation in these species. We believe this condition was caused by incomplete caudal autotomy, because only a portion of the tail bones and muscles were damaged. Although the old tail remained attached, the damage was severe enough to initiate the regeneration process, resulting in a new tail's growth in the injury site.

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References

Ahmadzadeh, F., Flecks, M., Carretero, M.A., Mozaffari, O., Böhme, W., Harris, D.J., et al. (2013): Cryptic speciation patterns in Iranian rock lizards uncovered by integrative taxonomy. PloS ONE **8**: e80563.

Alibardi, L. (2010): Morphological and cellular aspects of tail and limb regeneration in lizards: a model system with implications for tissue regeneration in mammals. Advances in Anatomy, Embryology and Cell Biology **207**: 1–109.

Bateman, P.W., Fleming, P.A. (2009): To cut a long tail short: a review of lizard caudal autotomy studies carried out over the last 20 years. Journal of Zoology **277**: 1–14.

Dial, B.E., Fitzpatrick, L.C. (1981): The energetic costs of tail autotomy to reproduction in the lizard *Coleonyx brevis* (Sauria: Gekkonidae). Oecologia **51**: 310–317.

Dudek, K., Ekner-Grzyb, A. (2014): Field observation of two-tailed sand lizard *Lacerta agilis* Linnaeus 1758, and a common lizard *Zootoca vivipara* (Jacquin, 1787) in Poland. Natura Sloveniae **16**: 65–66.

Fox, S.F., Heger, N.A., Delay, L.S. (1990): Social cost of tail loss in *Uta stansburiana*: lizard tails as status-signalling badges. Animal Behaviour **39**: 549–554.

Jagnandan, K., Russell, A.P., Higham, T.E. (2014): Tail autotomy and subsequent regeneration alter the mechanics of locomotion in lizards. Journal of Experimental Biology **217**: 3891–3897.

Koleska, D., Svobodová, V., Husák, T., Kulma, M., Jablonski, D. (2017): Tail bifurcation recorded in *Sauromalus ater*. Herpetology Notes **10**: 363–364.

Maginnis, T.L. (2006): The costs of autotomy and regeneration in animals: a review and framework for future research. Behavioral Ecology **17**: 857–872.

Martin, J., Avery, R.A. (1998). Effects of tail loss on the movement patterns of the lizard, *Psammodromus algirus*. Functional Ecology **12**: 794–802.

Martín, J., Salvador, A. (1992): Tail loss consequences on habitat use by the Iberian rock lizard, *Lacerta monticola*. Oikos **65**: 328–333.

Martin, J., Salvador, A. (1993): Tail loss reduces mating success in the Iberian rock-lizard, *Lacerta monticola*. Behavioral Ecology and Sociobiology **32**: 185–189.

McElroy, E.J., Bergmann, P.J. (2013): Tail autotomy, tail size, and locomotor performance in lizards. Physiological and Biochemical Zoology **86**: 669–679.

Midtgaard, R. (2019): RepFocus: a Survey of the Reptiles of the World. Middelfart, Denmark, published by the author. Available at: www.repfocus.dk.

Tamar, K., Maza, E., Meiri, S. (2013): Natural history notes. *Ophisops elegans* (Snake-Eyed Lizard). Bifurcation. Herpetological Review **44**: 146.

Vitt, L.J., Caldwell, J.P. (2013): Herpetology: an Introductory Biology of Amphibians and Reptiles. Fourth Edition. San Diego, California, USA, Academic Press. 757 pp.

Zani, P.A. (1996): Patterns of caudal-autotomy evolution in lizards. Journal of Zoology **240**: 201–220.

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