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NATURAL HISTORY NOTE

Balsas Basin Whiptail (*Aspidoscelis costatus costatus*) with Tail Bifurcation

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Tail functions in lizards take a variety of forms, which include: (1) aiding in locomotion by providing balance (Ballinger et al. 1973, Martin and Avery 1998); (2) storage of adipose tissue for energy reserves (Price 2017); (3) signaling of the lizard's social status (Fox et al. 1990); and (4) as an antipredator tactic through what is known as tail autotomy (Passos et al. 2016). Autotomy ("auto," Greek "self," and "tomy," Greek "cutting or incision", Higham et al. 2013), may be described as the autogenic detachment of a body structure which has evolved as disposable by the organism (Naya et al. 2007). Thus, in this case, caudal autotomy in lizards refers to the detachment of the tail when threatened by a predator at one of many either intra- or intervertebral fracture planes, serving as a decoy while the lizard escapes, as the lost tail flails and jerks around (Suárez-Rodríguez et al. 2020, Eberle et al. 2022). This incurs in a significant energetic loss and a reduction of fitness which may be compensated by the organism through changes in its behavior (Naya et al. 2007), while the tail regrows.

In some rare cases, however, both intra- and intervertebral autotomizing taxa present aberrations in the process of caudal regeneration, where more than one tail begins to develop (Barr et al. 2020). Usually, this takes the form of bifurcation, that is, retention of the original tail and development of a second tail from a fracture point. Such an event occurs after an imperfect autotomy event or considerable caudal injury, as the glial membrane that lines the spinal cord is disrupted (Barr et al. 2020). Families that have been reported to possess different degrees of bifurcation include: Agamidae (Ananjeva and Danov 1991), Anguidae (Conzendey et al. 2013), Gekkonidae (Lazcano et al. 2017), Gymnophthalmidae (Pheasey et al. 2013), Iguanidae (Koleska et al. 2017), Lacertidae (Kolenda et al. 2017, Koleska et al. 2017), Phrynosomatidae (Mata-Silva et al. 2013), Scincidae (Vergilov and Natchev 2017), Tropiduridae (Brasileiro 2021, Ramírez-Jaramillo 2022), and Teiidae (Pelegrin and Muniz-Leão 2016). In the family Teiidae, 15 out of 161 species have reports relating to abnormalities in caudal regeneration (Barr et al. 2020). Amongst them, members of the genus *Aspidoscelis* (Bateman and Chung-MacCoubrey 2013, Cordes and Walker 2013).

The Balsas Basin Whiptail (*Aspidoscelis costatus costatus*) is a moderately large species of lizard, with oviparous habits, and classified as an active forager (Aguilar-Moreno et al. 2010, Hernández-Gallegos and Domínguez-Vega 2012). It is endemic to Mexico and is found in a variety of habitats at different elevations within the states of Mexico, Guerrero, Morelos, Puebla, Tlaxcala, and Oaxaca (Granados-González et al. 2020). Albeit this last decade has seen a significant increment in the reports related to abnormal tail regeneration, e.g., Tropical Tree Lizard (*Urosaurus bicarinatus*; Mata-Silva et al. 2013), Common House Gecko (*Hemidactylus frenatus*; Lazcano et al. 2017), and Black-tailed Brush Lizard (*Urosaurus nigricaudus*; Álvarez et al. 2020), the availability of records related to the presence of tail bifurcation are still rather scant or anecdotical, especially within the State of Mexico, where we found only one article relating to this phenomenon on an individual of Cope's Skink (*Plestiodon copei*; Suárez-Rodríguez et al. 2020). Here, we discuss the first case of tail bifurcation discovered upon a population of *A. costatus costatus.*

On 12 May 2023, we found a juvenile male (sexual development according to Granados-González et al. 2015) *A. costatus costatus* (snout-vent length = 63 mm, tail length = 95 mm, mass = 6.5 g) within a 2,700 m^2 urban area near an asphalt road in Ixtapan de la Sal, State of Mexico, Mexico (18.8429°N, -99.6811°W, datum WSG84, 1,880 m. elev.). The individual was captured manually after attempting to hide under a pile of fallen leaves and branches, close to a chain link fence. We observed the specimen had a lateral tail bifurcation = 18 mm, at approximately a 45° angle, and at the distal third of the original tail; the last section possessed a warped, curly shape, tapering up to an end point (Figs. 1-2). According to the visual representation comparison made by Barr et al. (2020), the tail bifurcation may be classified as a regeneration from the original tail. And as per the classification made by Gómez-Benítez et al. (2020), it was determined that the specimen presented a dorsal color pattern class III (Zweifel 1959). The original portion of the tail presented medium sized, keeled, and oval scales, with a uniform shape, while the bifurcated portion of the tail possessed much smaller and asymmetrical scales, which in many cases seemed to overlap one another, thus, making them morphologically quite different from the original portion of the tail (Fig. 2). It is also important to note that the original tail, at the point of bifurcation, shows a pair of significantly larger keeled rows of

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Fig. 1. Juvenile male of *Aspidoscelis costatus costatus* at Ixtapan de la Sal, State of Mexico, Mexico, that presents caudal bifurcation. Photo by Edgar Oviedo-Hernández.

scales, which follow a few rows of asymmetric scales, before once more acquiring the uniform shape that characterized the proximal and middle sections of the original tail.

This specimen was the only one, from a total of 157 individuals that we captured (63 in June and July, 30 in November 2022, and 64 in April and June 2023, with a total of 71 males and 86 females), that presented this tail bifurcation. In a populational scale, it seems that tail bifurcation is a very rare occurrence, with a frequency of about 0.64% within this population of *A. costatus costatus*. As it is likely that cases such as this are misrepresented or not reported upon, we encourage the publication of data relating to abnormal tail regeneration, as several aspects relating to these events are still unknown or poorly understood, such as how frequent tail abnormalities are within a population, the ecological effects, and its influence upon lizard survival.

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Fig. 2. Close up of the tail bifurcation of *Aspidoscelis costatus costatus* at Ixtapan de la Sal, State of Mexico, Mexico. Photo by Edgar Oviedo-Hernández.

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