CAUDATA — SALAMANDERS

***AMBYSTOMA JEFFERSONIANUM* (Jefferson Salamander). TAIL BIFURCATION.** Salamanders are known for their exceptional tissue regenerative capabilities (Joven et al. 2019. Development 146:dev167700). Their ability to regenerate amputated tails has in particular been heavily investigated in the field of developmental biology and serves as a critical model for understanding spinal cord repairing and regeneration (Tazaki et al. 2017. Dev. Biol. 432:63–71). Tail bifurcation, the phenomenon of growing or regenerating a tail with a forked end, has been reported in salamanders and can be surgically induced in the laboratory. However, tail bifurcation in salamanders remains a rare occurrence in the wild, with causes yet to be identified (Henle et al. 2012. J. Herpetol. 46:451–455). A large portion of salamander tail bifurcation cases to date have been reported in the widespread North American ambystomatids, with detailed documentations in five species: *Ambystoma laterale* (Blue-spotted Salamander), *A. maculatum* (Spotted Salamander), *A. talpoideum* (Mole Salamander), *A. opacum* (Marbled Salamander), and *A. tigrinum* (Tiger Salamander) (Semlitsch et al. 1981. Herpetol. Rev. 12:69; Williams et al. 2008. Biol. Lett. 4:549–552; Baxter et al. 2021. Herpetol. Rev. 46:812–813; Wang 2022. Herpetol. Rev. 53:275–276; Stevens 2022. Herpetol. Rev. 53:639). Here, I report the first known observation of tail bifurcation in *A. jeffersonianum*.

Fig. 1. *Ambystoma jeffersonianum* with tail bifurcation from Stanhope, New Jersey, USA.

At 2247 h on 31 March 2022, in Stanhope, New Jersey, USA (40.91778°N, 74.75500°W; WGS 84), I observed an adult *A. jeffersonianum*, of unknown sex, with a tail bifurcation. The *A. jeffersonianum* was found crossing a paved road, moving towards a known breeding pond of the species. Its tail bifurcating point was followed by a primary tail growing along the original long axis of the body. The irregular dorsal surface of the primary tail indicated potential previous tail truncation or trauma. A secondary tail was extended from the dorsolateral side of the bifurcating point and was perpendicular to the height of the primary tail. Both tails appeared to be mobile, and the bifurcation did not hinder the mobility of the salamander. The *A. jeffersonianum* was photographed on-site (Fig. 1) and released at the capture location. *Ambystoma jeffersonianum* is abundant at this location. Along with *A. maculatum*, *A. jeffersonianum* is frequently observed moving across roads on rainy nights during the breeding season. Two other salamander species, *Hemidactylium scutatum* (Four-toed Salamander) and *Notophthalmus viridescens* (Eastern Newt), are also common in this area. However, to the best of my knowledge, this is the first case of tail bifurcation of any salamander species at the site.

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***AMBYSTOMA LATERALE-JEFFERSONIANUM* COMPLEX (unisexual *Ambystoma*). POLYDACTYLY.** Polydactylism (supernumerary digits) and, to a lesser extent, polymelia (supernumerary limbs) have been broadly observed in amphibians for well over a century (Rothschild et al. 2012. Herpetological Osteopathology: Annotated Bibliography of Amphibians and Reptiles. Springer, New York, New York. 450 pp.). Various factors contribute to the development of limb malformations in amphibians, including extrinsic stressors such as UV radiation, chemical pollutants, pathogens (Ankley et al. 2004. Ecol. Env. Safety 58:7–16; Johnson et al. 2003. Conserv. Biol. 17:1724–1737; Williams et al. 2008. Biol. Letters 4:549–552), physical trauma (Thompson et al. 2014. Regeneration 1:27–32), poor habitat quality (Soto-Rojas et al. 2017. PLoS ONE 12:e0183573), and genetic variation (Lange and Müller 2017. Quart. Rev. Biol. 91:1–38). Accounts of physical abnormalities in amphibians are important for better understanding developmental processes and monitoring spatial and temporal trends that may be

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Fig. 1. A unisexual salamander of the *Ambystoma laterale-jeffersonianum* complex from Maine, USA, exhibiting polydactyly.

associated with amphibian population declines. Here, we present an observation of polydactyly in a unisexual salamander from the *Ambystoma laterale-jeffersonianum* complex. All handling and tissue collection was done under proper permits (UMaine IACUC permit A2023-02-02, Maine IF&W Scientific Collection Permit 2023-686).

The salamander was captured on 18 April 2024 in an aquatic funnel trap in a forested vernal pool in Old Town, Maine, USA (44.9°N, 68.7°W; WGS 84; 32.6 m elev.), during a population study on breeding adult amphibians. Out of 154 *Ambystoma* salamanders collected at this population and out of 781 *Ambystoma* collected in the local study area over two years, no other limb abnormalities have been observed. The salamander had an SVL of 6.8 cm, a total length of 13.2 cm, and a weight of 9.9 g. A small tail clip was obtained from the individual to confirm the species identity as Unisexual *Ambystoma* (biotype not determined) via mitochondrial sequencing. The salamander exhibited polydactyly on its left foot (Fig. 1), with 10 digits growing from a single limb in a roughly symmetrical fashion and appearing as two feet fused together. One digit grew independently from the limb, offset immediately above the plane of the foot. We did not take an X-ray or conduct histological analysis to further characterize bone anatomy and potential underlying causes (e.g., trematode infection). It is unclear whether the salamander had further bone duplication consistent with polymelia.

Malformations have been reported widely in anurans and salamanders, including various species in the genus *Ambystoma* (e.g., Bishop and Hamilton 1947. Science 106:641–642) and in the Unisexual *Ambystoma* (Lannoo M. 2008. Malformed Frogs: The Collapse of Aquatic Ecosystems. University of California Press, Berkeley, California. 270 pp.). However, explicit documentation of polydactyly or polymelia in Unisexual *Ambystoma* is limited, as is comparison of malformations between Unisexual *Ambystoma* and co-occurring sexual *Ambystoma* species. Unisexual *Ambystoma*, especially those with higher levels of ploidy, have been found to display greater tail coiling, spinal curvature (Phillips et al. 1997. J. Herpetol. 31:530–535), and tissue regeneration rates (Saccucci et al. 2016. J. Zool. 300.2:77–81) than sexual species. Other characteristic morphological abnormalities are not known in Unisexual *Ambystoma*.

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***PLETHODON CINEREUS* (Eastern Red-Backed Salamander). SCOLIOSIS.** Skeletal abnormalities in amphibians may be caused by environmental contaminants, pathogens, injury, or developmental errors (Danto and McGuire 2022. Zoomorphology 141:209–220). There are few reports of scoliosis in plethodontid salamanders (e.g., *Plethodon glutinosus*, Marvin 1995. Herpetol. Rev. 26:30; *Eurycea junaluska*, Ryan 1998. Herpetol. Rev. 29:163; *P. idahoensis*, Peterson et al. 1999. Herpetol. Rev. 30:222; *Pseudotriton ruber*, Haines-Eitzen 2016. Herpetol. Rev. 47:276). Here, we report the first observation, to our knowledge, of scoliosis in *Plethodon cinereus*.

Plethodon cinereus is a widespread lungless salamander found in mainland eastern North America, inhabiting temperate forest floors within its native range. However, one established population exists outside of its native range, on the island of Newfoundland, Canada (Baxter-Gilbert et al. 2022. Can. Field-Nat. 136:5–9). The history and status of this population is currently unknown and under investigation.

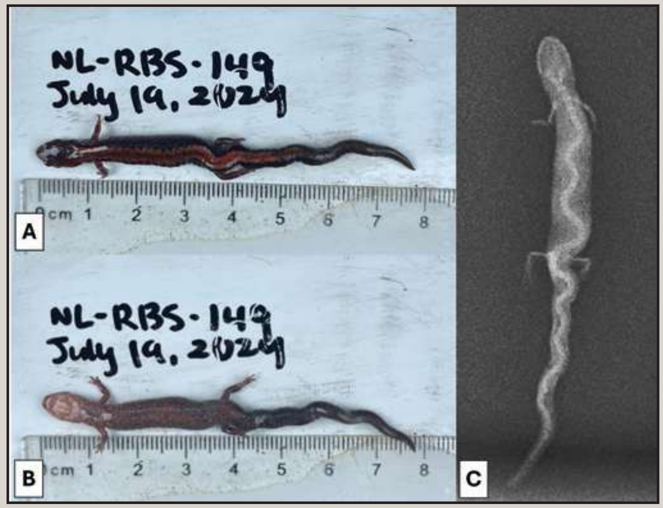

Fig. 1. *Plethodon cinereus* exhibiting scoliosis from the dorsal (A) and ventral viewpoints (B). A radiograph showing the skeletal structure of this individual's spine (C).

On 19 July 2024 at 1530 h, while surveying for *P. cinereus* in Newfoundland, we captured an adult *P. cinereus* (44 mm SVL, 77 mm total length; 1.06 g) in a residential woodlot located in Conception Bay South, Newfoundland, Canada (47.5073°N, 52.9965°W; WGS 84). The *P. cinereus* was found under a rock with a substrate temperature of 18.7°C, while the ambient air temperature was 22.4°C. We determined the *P. cinereus* to be male due to prominent cirri and an angular nose (Rucker et al. 2021. J. Fish Wildl. Manag.12:585–603). The *P. cinereus* appeared to exhibit sciolosis (Fig. 1A, 1B), which was confirmed from a radiograph of the individual's spine (Fig. 1C). The *P. cinereus* did not appear to have any issues with locomotion, suggesting that its condition was not due to recent trauma or injury and was likely congenital. Similarly, the color and pattern on the tail suggest that there was no tail autotomy or regeneration (Fig. 1A, 1B).

There are several potential factors that may have caused this salamander's scoliosis. First, the immediate habitat of this *P. cinereus* is a developed residential landscape, and the salamander may have been exposed to environmental pollutants from anthropogenic sources (e.g., Alvarez et al. 1995. Arch. Environ. Contam. Toxicol. 28:349–356). This invasive population has been seen ingesting microplastics (Williams et al. *in press*. Herpetol. Rev.). Second, due to the isolated nature of this population from the rest of the geographic range of *P. cinereus*, the reduction of gene flow over time may have led to an inbreeding depression in this population, which might contribute to mutations in the genome that lead to impaired development (e.g., inbreeding in lizards, Olsson et al. 1996. J. Evol. Biol. 9:229–242). However, previous work on *Ambystoma tigrinum* (Tiger Salamander) found no correlation between deformity rates and inbreeding (Williams et al. 2008. Biol. Lett. 5:549–552). Given that this deformity was seen in only 0.59% of the sampled individuals (N = 171), it appears that rates of scoliosis remain low within this invasive population.

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