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Polymelia, polydactyly and other malformations in adult *Salamandra salamandra* from the Valle del Tiétar

Walter Cantero

Cl. Corregidor Juan Francisco de Luján, 92. Bajo B. 28030 Madrid. Spain . C.e.: waltercanteromorales@gmail.com

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RESUMEN: En noviembre de 2023 se localiza en el Valle del Tiétar un ejemplar adulto de *Salamandra salamandra* con diversas malformaciones. El ejemplar presenta polimelia, apareciendo duplicada la extremidad anterior izquierda. Dicha extremidad supernumeraria posee un tamaño reducido y nace en la zona axilar bajo una extremidad de mayor tamaño. Se observa polidactilia en la extremidad anterior izquierda de mayor tamaño, donde aparecen seis dedos en vez de los cuatro esperados. Dichos dedos presentan tamaños dispares y una disposición aberrante. Las malformaciones descritas obstaculizan la locomoción del animal, ya que la extremidad de mayor tamaño nunca apoya sobre el suelo y no es funcional debido a las malformaciones que afectan a su región proximal. Pese a las desventajas motrices que suponen dichas malformaciones para su supervivencia, el ejemplar muestra aparentemente un buen estado y condición física. En febrero de 2024, el ejemplar vuelve a ser localizado sano en la misma ubicación.

Among the urodeles from the Iberian Peninsula, teratological developmental malformations affecting the limbs are observable and have been reported in both larval (Escori-

za & García-Cardenete, 2005; Couto & Rebelo, 2022) and adult specimens (Sequeira *et al.*, 1999; Diego-Rasilla, 2000; Ortiz *et al.*, 2006; Villanueva, 2007; Diego-Rasilla, 2009; Galán, 2011; Martínez-Silvestre



Figure 1: Adult *Salamandra salamandra* specimen with malformations affecting the left forelimb located in the area of Las Juntas in the Valle del Tiétar, Ávila.

Figura 1: Ejemplar adulto de *Salamandra salamandra* con malformaciones en la extremidad anterior izquierda localizado en el entorno de Las Juntas en el Valle del Tiétar, Ávila.

et al., 2014; Zamora-Camacho, 2016; Burón, 2019; Zamora-Camacho & Medina-Gálvez, 2019; Poch & Carné, 2021), being *S. salamandra* from urban populations a notorious case of high incidence and multiple deformities in terrestrial amphibians (Velo-Antón *et al.*, 2021). There are several types of these deformities to which we will make reference herein: polymelia and polydactyly, the presence of a higher than normal number of limbs or toes, respectively; brachymelia and brachydactyly, which are the result of the shortening or reduction of the size of the limbs and toes, respectively; micromelia, when the limb is complete but shows a reduced size and an underdeveloped appearance (Meteyer, 2000).

On November 9, 2023, at 14:30, four adult *Salamandra salamandra* specimens were located in the southern area of UTM grid UK56, at 505 masl, by active searching, turning over rocks and seeking out potential hiding places. The sighting took place in the natural environment of Las Juntas, meeting site between the Escorial and Tiétar rivers, on the border between the municipalities of La Adrada and Piedralaves, Ávila. This locality

falls within the *S. s. bejarae* range (Antunes *et al.*, 2021) as does the coloration pattern of the specimens found (Velo-Antón & Buckley, 2015). Fire salamanders from this area have been molecularly characterised previously (Martínez-Solano *et al.*, 2005; Pereira *et al.*, 2016). One of the salamanders showed various malformations affecting the left forelimb (Figure 1).

The presence of polymelia is noteworthy, with the left forelimb being duplicated. The supernumerary limb arose from the axillary area of the larger main limb, just beneath it. This duplicated forelimb showed a low degree of development compared to the other

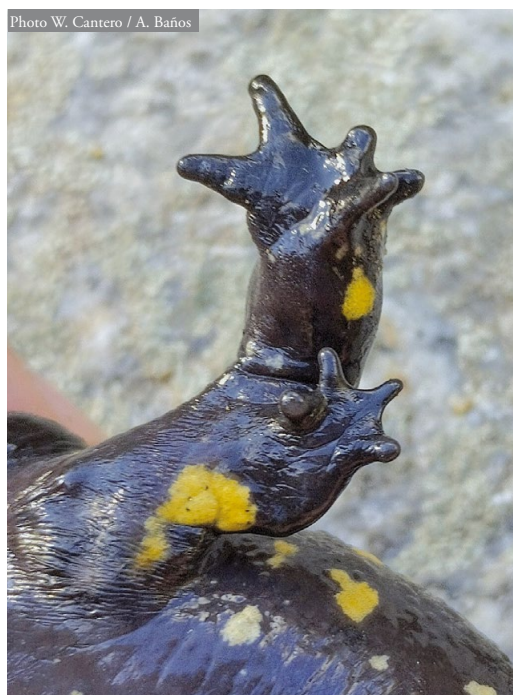


Figure 2: Detail of the polymelia and micromelia. The left forelimb is duplicated and an undersized supernumerary limb emerges from the axillary region. This limb is reduced in size compared to the other salamander limbs.

Figura 2: Detalle de la polimelia y micromelia. La extremidad anterior izquierda aparece duplicada y un miembro supernumerario de tamaño reducido surge de la región axilar. Dicho miembro presenta, en su conjunto, un tamaño reducido comparado con el resto de las extremidades de la salamandra.

Photo A. Baños



Figure 3: The main and larger left forelimb appears displaced and immobilized in an elevated position and never rests on the ground. Photograph taken in February 2024 after locating the same specimen again.

Figura 3: El miembro anterior izquierdo principal y de mayor tamaño aparece desplazado e inmovilizado en una posición elevada y nunca se apoya en el suelo. Fotografía tomada en febrero de 2024 tras localizar nuevamente al mismo ejemplar.

limbs and had four miniaturized but proportional toes in relation to the overall reduced size of the limb. It is therefore a case of micromelia (Figure 2). Polymelia in fire salamanders from the Iberian Peninsula has been previously documented in the literature twice (Velo-Antón & Buckley, 2015), once in Málaga (Escoriza & García-Cardenete, 2005) and once in Asturias (Villanueva, 2007).

The main and larger left forelimb was shorter but stouter than the right forelimb, non-functional and appeared displaced and immobilized in an elevated position owing to the insertion of the smaller forelimb underneath it (Figure 3). Further examination revealed several other developmental malformations. This larger left forelimb also exhibited polydactyly, with six toes instead of the expected four. These

Photo W. Cantero / A. Baños



Figure 4: Detail of the polydactyly and brachydactyly. The development of six toes is observed instead of the expected four. They show an aberrant arrangement, as well as disparate sizes, with brachydactyly present in three of the toes.

Figura 4: Detalle de la polidactilia y braquidactilia. Se observa el desarrollo de seis dedos en lugar de los cuatro esperados. Estos muestran una disposición aberrante, así como tamaños dispares, con braquidactilia presente en tres de los dedos.

Photo W. Cantero / A. Baños

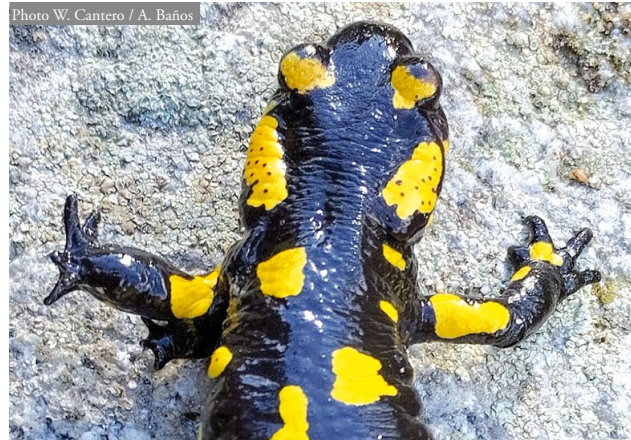


Figure 5: Detail of the brachymelia and comparison with the right forelimb. The left forelimb is shorter but stouter. The proximal region of the leg is reduced, the forearm being directly attached to the body.

Figura 5: Detalle de la brachimelia y comparativa con la extremidad anterior derecha. La extremidad anterior izquierda es más corta pero más gruesa. La región proximal de la pata aparece reducida, estando el antebrazo directamente unido al cuerpo.

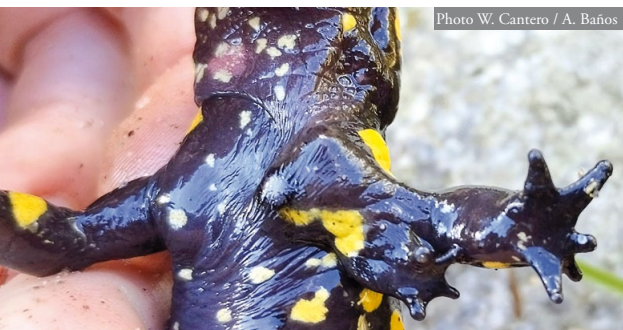


Figure 6: Detail of the malformation in the ventral thoracic region connecting to the left forelimbs. A triangular-shaped bony structure, presumably the scapula, can be seen under the skin.

Figura 6: Detalle de la malformación en la región torácica ventral que conecta con los miembros anteriores izquierdos. Se observa una estructura ósea de forma triangular, presumiblemente la escápula, bajo la piel.

toes displayed an aberrant arrangement, as well as disparate sizes, with brachydactyly being observed in three of the toes (Figure 4). Given the impossibility of radiographic examination, it is not possible to determine with certainty the condition, origin and skeletal composition of the limb abnormalities. Albeit limb curtailment evinces the existence of brachymelia and the proximal region of the leg is reduced, it is not possible to determine to what extent the proximal region of the limb (humerus) and the elbow joint are affected (Figure 5). Furthermore, in the ventral thoracic region of the animal, connecting with the left forelimbs, a triangular-shaped bony structure, presumably the scapula, was evident under the skin, which was not observed at the basal region of the right forelimb (Figure 6).

The cause of the malformations of this specimen cannot be clarified and no exact explanation for their formation can be given. It is possible that they were already present in the larval stage and manifested during the early development of the animal (Escoriza & García-Cardenete, 2005) or that they are attributable to a defective regenera-

tion process after the specimen has suffered some sort of injury (e.g. predator attacks). However, the causes of limb and other amphibian deformities are multiple and have been variously explained as including anthropogenic factors such as pollution, pesticides and agrochemicals; abiotic factors, for instance UV-B radiation or temperature; and biotic factors like parasitic infections, inbreeding, as well as injuries caused by predators (Blaustein *et al.*, 1997; Ouellet *et al.*, 1997; Stopper



Figure 7: Capture of a video showing the animal's locomotion. The animal employs the reduced left forelimb as a support point while the larger left forelimb remains immobilized in an elevated position and never rests on the ground. Its gait is comparable to that of a salamander with only one forelimb.

Figura 7: Captura de un video que muestra la locomoción del animal. El ejemplar emplea el miembro anterior izquierdo reducido como punto de apoyo mientras que la extremidad anterior izquierda de mayor tamaño permanece inmovilizada en una posición elevada y nunca toca el suelo. Su desplazamiento es comparable al de una salamandra con una sola extremidad anterior.

et al., 2002; Blaustein & Johnson, 2003; Johnson *et al.*, 2003; Ankley *et al.*, 2004; Dourmon *et al.*, 2005; Taylor *et al.*, 2005; Bowerman *et al.*, 2010; Lunde & Johnson, 2012; Velo-Antón *et al.*, 2021).

The malformations described hinder the animal's locomotion, as the larger limb never rests on the ground, remaining immobilized in a position above the frontal plane of the animal, and does not appear to have a structural development, notwithstanding its size, compatible with locomotion. Its mobility is compromised due to the malformations affecting the proximal region of the left forelimb and its motion is comparable to that of a salamander with only one forelimb. It can be observed how the animal employs the small axillary limb as a

support point during its gait (Figure 7). While the other *Salamandra salamandra* specimens located were sheltered under rocks, where they had gained access by digging in the soil, the specimen with malformations was pressed against the margin of a rock and might have some of its motor skills, such as burrowing or climbing, impaired. Lacking this abilities and with a reduced capacity for locomotion, the survival of this specimen faces a clear handicap which it has nevertheless been able to compensate by reaching reproductive adulthood and otherwise appearing completely healthy. In February 2024, this same specimen was again located in good physical condition at the same site (Figure 3).

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First report of polymelia in *Epidalea calamita*

Helena Martínez-Gil^{1*} & Iñigo Martínez-Solano²

¹ Departament de Biologia Evolutiva, Ecologia i Ciències ambientals. Universitat de Barcelona. 08028 Barcelona. Spain. C.e.: helenamartg95@gmail.com

² Departamento de Biodiversidad y Biología Evolutiva. Museo Nacional de Ciencias Naturales-CSIC. Cl. José Gutiérrez Abascal, 2. 28006 Madrid. Spain.

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RESUMEN: En abril de 2022 se encontró una hembra de sapo corredor (*Epidalea calamita*) con polimelia en la Sierra de Guadarrama (Comunidad de Madrid, España), durante un muestreo diurno. La malformación consistía en la presencia de una extremidad adicional, aparentemente osificada pero no funcional, en posición ventral. Esta observación constituye el primer caso de polimelia documentado en la especie.

Amphibians are the most threatened group of vertebrates, with many species showing negative trends at the global scale (Wake & Koo, 2018). Concern about the health of amphibian populations has promoted studies focusing on potential stressors, with morphological malformations emerging as a significant threat due to their potential ecological and demographic consequences. These deformities directly

affect individual fitness (Møller, 1997; Mirajover *et al.*, in press), increasing predation risk and mortality, which may eventually have an impact on population dynamics. Morphological malformations usually occur with a basal prevalence rate around 2–5% in natural amphibian populations (Johnson *et al.*, 2010), but when their incidence exceeds this threshold they can become a potential risk for popula-