FIRST RECORD OF UNILATERAL ANOPHTHALMIA IN *ANAXYRUS BOREAS HALOPHILUS* (BAIRD AND GIRARD, 1852) (ANURA: BUFONIDAE) IN ENSENADA, BAJA CALIFORNIA, MEXICO

PRIMER REGISTRO DE ANOFTALMIA UNILATERAL EN *ANAXYRUS BOREAS HALOPHILUS* (BAIRD Y GIRARD, 1852) (ANURA: BUFONIDAE) EN ENSENADA, BAJA CALIFORNIA, MÉXICO

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Resumen.– Se registra por primera vez un caso de anoftalmia unilateral en *Anaxyrus boreas halophilus*. Este registro contribuye al conocimiento de esta anomalía en anfibios mexicanos.

Keywords.– Anoftalmia, anomalía del desarrollo, malformación ocular, visión lateral, anuros.

Abstract.– A case of unilateral anophthalmia is reported for the first time in *Anaxyrus boreas halophilus*. This record contributes to the knowledge of this anomaly in Mexican amphibians.

Palabras clave.– Anophthalmia, anurans, developmental anomaly, lateral vision, ocular malformation.

Anophthalmia is characterized by the absence of ocular tissue in the orbit (Verma & FitzPatrick, 2007). Due to the lack of ocular tissue, this anomaly results in a hollow depression covered by skin, with no trace of a supraocular protuberance or eyelid (Ganesh & Arumugam, 2015; Henle et al., 2017; Morales-Flores et al., 2021). This condition significantly impacts survival, as vision is essential for spatial perception, orientation, depth perception, barrier and surface discrimination, predator detection, and both prey localization and selection (Ingle, 1976; Ramalho et al., 2017).

Visual capability is considered essential and varies among species, genera, or families of amphibians depending on their habits (Boss & Plummer, 2022). This variation depends on several factors, including "visual lateralization", which in amphibians refers to the specialization of the right and left brain hemispheres in controlling different behavioral responses or processing sensory information differently. For example, the left eye/right hemisphere is more sensitive to threatening stimuli, social cues, and the identification of novel prey. Meanwhile, the right eye/left hemisphere focuses more on familiar prey or stimuli in non-threatening environments (Robins, 2005).

Visual communication, combined with other types of communication such as auditory, chemical, or tactile, facilitates the transmission of crucial information between individuals (Rösel de Lourenço et al., 2020; Augusto-Alves & Toledo, 2021). Furthermore, this type of communication influences individuals' ability to survive and perform various activities, such as courtship

and reproduction or during escape mechanisms through the recognition of objects, predators, or barriers in low ambient light conditions (Staub et al., 2020; Ancillotto et al., 2022).

On July 28, 2024, at 8:12, during a hiking at the shores of Laguna Hanson (32.046° N, 115.910° W, 1,620 m a.s.l.), located within the Protected Natural Area of the Parque Nacional Constitución de 1857 (PNC-1857), in Ensenada, Baja California, Mexico. We observed approximately twenty organisms of *Anaxyrus boreas halophilus* along the lagoons' edges (none of which exhibited visible anomalies). Upon noticing our presence, the organisms fled; however, one individual did not escape. The individual was a juvenile *A. boreas halophilus* (31.19 mm snout-vent length) (Fig. 1a) with an absence of supraocular protuberance and eyelid, showing only a small remnant where the right eye should be (Fig. 1b). The individual was photographed in situ with a reference scale and its SVL was estimated in the image J software. Given that no additional injuries were observed, it is plausible to attribute the absence of the eye to anophthalmia rather than to a predation attempt.

We identified the organism because *A. boreas halophilus* is less blotched (reduced dorsal melanin) than *A. boreas boreas*, has a wider head and larger eyes, smaller feet, and a weaker development of the margins along the dorsal stripe. Juveniles are patterned like the adults, but may have red warts dorsally, and they lack the white mid-dorsal stripe. They also have bright yellow or orange flecks on the bottoms of their feet and body (Dodd, 2023).

Different factors may cause this anophthalmia, including ultraviolet radiation (Blaustein & Johnson, 2003; Ankley et al., 2004; Castro-Torreblanca & Blancas, 2021), parasites (Johnson et al., 2002; Johnson & Lunde, 2005; Rajakaruna et al., 2008; Castro-Torreblanca & Blancas, 2021), inbreeding caused by founder effects (Williams et al., 2008; Toledo & Ribeiro, 2009; Castro-Torreblanca & Blancas, 2021), environmental contaminants such as metals and petroleum hydrocarbons (Bacon et al., 2013; Castro-Torreblanca & Blancas, 2021; Swastik et al., 2024) and pesticides (Hayes, 2005; Robles-Mendoza et al., 2009; Castro-Torreblanca & Blancas, 2021). However, these causes may induce this anomaly independently or in combination.

The vegetation surrounding Laguna Hanson consists of mountain pine forest (*Pinus jeffrey*) with elements of mountain chaparral vegetation (*Adenostoma sparsifolium*) and grasslands, which is the dominant plant community in the lagoon's floodplain (Delgadillo, 1998). Traditionally, the area around Laguna Hanson has been used for extensive cattle ranching by ranchers living in nearby regions of PNC-1857. When water levels in the lagoon drop, these areas become ideal for cattle grazing, which may lead to pesticide or insecticide residues reaching the lagoon, potentially using cattle as a transport medium (Delgadillo, 1998). The area is also a site for uncontrolled recreational activities, and urban solid waste is commonly found around the lagoon.

Due to the fact that anurans have visual lateralization and do not have perceptual systems reflected in both cerebral hemispheres, we can hypothesize that the absence of the right eye

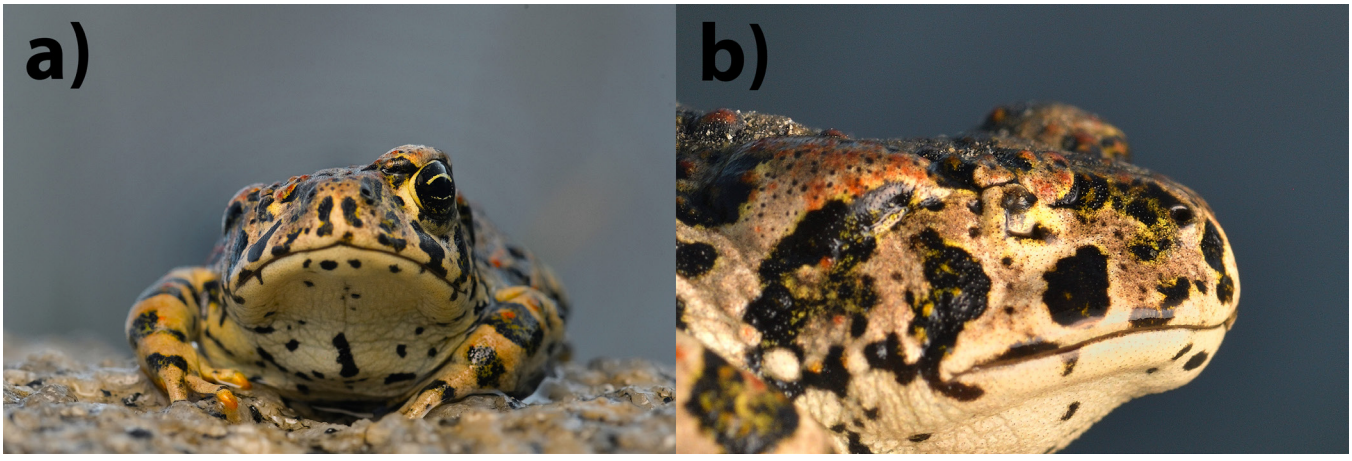

Figura 1. Vista frontal (a) y lateral (b) de individuo juvenil de *Anaxyrus boreas halophilus* con anoftalmia unilateral en el ojo derecho, registrado en el Parque Nacional Constitución de 1857, Ensenada, Baja California, México. Foto: Leonardo Ponce Rosales.

Figure 1. Frontal (a) and lateral (b) view of a juvenile individual of *Anaxyrus boreas halophilus* with unilateral anophthalmia in the right eye, recorded in Parque Nacional Constitución de 1857, Ensenada, Baja California, Mexico. Photo: Leonardo Ponce Rosales.

affects the detection of prey and the recognition of a threatening environment (Robins, 2005), which could explain why the frog did not notice our presence when we approached from its right side. However, it is important to mention that studies on the laterality of visual processing in anurans show that the degree of lateralization is modifiable with experience (Robins, 2005). This could explain why the organism we found has survived, because its visual processing has been modified, allowing it to attend to all stimuli and process them as an organism with both eyes. However, the cost of not having one eye may end up having repercussions on the efficiency of reception and processing of stimuli, or simply the organism may not be able to process some stimuli.

The current record of anophthalmia in *A. boreas halophilus* contributes to the understanding of this anomaly in Mexican amphibians and represents the first reported case in this species. Further studies on visual lateralization, as well as the prevalence and causes of this anomaly at the population level, are needed to gain a better understanding of anophthalmia in *A. boreas halophilus* and other amphibian populations.

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