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Short Communication

Ocular anomalies in two species of *Osteocephalus* (Anura: Hylidae) from the Amazonian region of northern Brazil

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Anomalies may affect anurans during their initial phase of development, as well as by extrinsic factors that alter organs or structures that were formed correctly (Meteyer 2000, Henle *et al.* 2017a), such as exposure to chemical pollutants or UV-radiation (Lannoo 2009, Agostini *et al.* 2013), parasitic or virulent infections (Kiesecker 2002), and attacks thwarted by predators (Borges *et al.* 2019); in some cases, these factors may interact (Toledo and Ribeiro 2010, Bionda *et al.* 2012, Henle *et al.* 2017a). In wild populations not exposed to external contaminants, the occurrence of anomalies typically does not exceed 5% (Ouellet 2000, Blaustein and Johnson 2003). Studies around the world indicate that limb anomalies are prevalent in anuran populations (e.g., Henle *et al.* 2017a, b, Pedroso-Santos *et al.* 2020, Souza *et al.* 2021). In Brazil, for instance, a recent review of anuran anomalies showed that the majority of records is anecdotal, and their consequences on individual survival and reproduction, as well as on larger population processes, are underestimated (Souza *et al.* 2021). Despite this, anecdotal observations related to anomalies in poorly known species add relevant information for future ecological studies. This condition may affect survival and ultimately increase our knowledge of this phenotypic variation.

Regarding the nomenclature of anuran anomalies, Henle *et al.* (2017b) argued that the terms "malformations" and "deformities" may be outdated because many studies erroneously use these terms to detail whether they are external or osteological. Therefore, the term "anomalies" has been most frequently used to designate such non-typical phenotypes in a generalized way (Henle *et al.* 2017a, b). To specifically designate anomalies occurring in the eye, several terms have been used in the

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literature, such as black-eyedness, heterochromia, perforated eye, opacity of the eye, and microphthalmia (see Ingle 1976, Toledo and Ribeiro 2010, Pedroso-Santos *et al.* 2020, Souza *et al.* 2021). All of these terms can be placed under the general term of ocular anomaly.

In this paper, we report cases of black-eyedness and heterochromia (according to Henle *et al.* 2017b) in the arboreal hylids *Osteocephalus* sp. and *O. oophagus* Jungfer and Schiesari, 1995, respectively, from a well-preserved forested area in the eastern Amazonian rainforest. Field observations were made within at the Reserva Extrativista Municipal Beija-Flor Brilho de Fogo (REMBFBF) (0.7918° N, 51.9783° W), municipality of Pedra Branca do Amapari, Amapá state, Brazil. This area is characterized by dense forest with sandy and clayey soil, which has a high degree of acidity and low fertility (Drummond *et al.* 2008, Lima 2008). Both species are known to occur in this area and are easily distinguished from the other co-occurring congeneric species (Faivovich *et al.* 2005, Dewynter *et al.* 2016).

The first observation was made on 17 October 2020 at about 19:30 h. An individual of *Osteocephalus* sp. was found perched on a branch approximately 1.50 m above a bank of the Água Fria River (0.7918° N, 51.9784° W; Datum WGS84; 110 m a.s.l.). We noticed that its left eye had an abnormal color, and apparently its left eyeball was enlarged (Figure 1A); following Henle *et al.* (2017b), this condition is known as "black-eyedness." It is a normal phenotype in some anuran species (e.g., dendrobatids) [e.g., caused by the lack of iridophores, a reduction of xanthophores, and a predominance of melanophores (Dubois 1976)]. We observed an unusual behavior that might be related to this ocular anomaly. When a researcher standing behind the frog perched on a branch moved a hand parallel to the left side of the frog (with the normal eye), it tended to change its position. When this movement was done on the right, with the black eye, the individual did not react, suggesting some degree of loss of vision. The absence of vision or low vision in anurans may be detrimental, possibly causing an inability to perceive potential predators. This individual of *Osteocephalus* sp. was collected and deposited in the Herpetological Collection of the Universidade Federal do Amapá (CECCAMPOS 3594).

The second observation occurred on 25 March 2022 at about 11:30 h. We found an individual of *O. oophagus* perched on a branch approximately 1 m above the ground (0.7955° N, 52.2602° W; Datum WGS84; 190 m a.s.l.). This individual had different iris colors in each eye. The right eye was gray with black rays, whereas the left eye was the usual gold with black rays (Figure 1B). According to Henle *et al.* (2017b), this condition is referred to as heterochromia. Heterochromia may be related to genetic factors in animals (Bond 1913), and this anomaly is characterized by the difference in pigmentation between the eyes. Only one eye has the typical pigmentation of the species, but both eyes have normal characteristics such as iris size and rays (Henle *et al.* 2017b).

Our reports are anecdotal but add information about the natural history and phenotypic variation of these two species of *Osteocephalus.* Cases of ocular anomalies are rarely described in the literature (e.g., Ramalho *et al.* 2017, Sousa and Costa-Campos 2017, Brassaloti and Bertoluci 2018, Mônico *et al.* 2019, Pedroso-Santos *et al.* 2020, Souza *et al.* 2021), and to our knowledge, no reports in the literature associate black-eyedness with blindness. Black-eyedness in anurans is related to habitat disruption (e.g., Guerra and Aráoz 2016, Gurushankara *et al.* 2007). However, our observations come from a well-preserved forested area, in which there are no reports of anomalies in animals or of environment degradation. Although ocular anomalies have been described in non-contaminated habitats (e.g., Eaton *et al.* 2004, Ramalho *et al.* 2017), their causes are not fully understood. Further studies on the origins of anomalies and their consequences are needed. We encourage researchers to describe ocular anomalies in future studies of anurans.

Figure 1. Specimens of *Osteocephalus* with ocular anomalies at the Reserva Extrativista Municipal Beija-Flor Brilho de Fogo, municipality of Pedra Branca do Amapari, Amapá state, Brazil. **(A)** Black-eyedness in *Osteocephalus* sp. (CECCAMPOS 3594), and **(B)** heterochromia in *O. oophagus.*

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