

Back from extinction: rediscovery of the harlequin toad *Atelopus mindoensis* Peters, 1973 in Ecuador

César L. Barrio Amorós¹, Melissa Costales², Jose Vieira³, Eric Osterman⁴,
Hinrich Kaiser⁵, and Alejandro Arteaga^{3,*}

Harlequin toads (genus *Atelopus* Duméril & Bibron, 1841; Bufonidae) are the vertebrate genus that appears to have suffered the most dramatic population declines throughout their range in the Neotropics over the past several decades (La Marca, 2005; Scheele et al., 2019). As a focal point for harlequin toad diversity, Ecuador possesses the second-highest number of species (25), and of these, 18 (72%) are endemic to Ecuador (Centro Jambatu, 2011–2017). Thirteen of these 25 species (52%) have not been seen since the late 1980s or early 1990s (La Marca et al., 2005; Coloma et al., 2010). As a consequence, all 25 species are currently categorized as threatened in Ecuador according to IUCN Red List criteria (IUCN, 2012): ten are classified as Critically Endangered (Possibly Extinct), 14 as Critically Endangered, and one as Endangered (Centro Jambatu, 2011–2020).

One of the species in the CR (Possibly Extinct) category is *Atelopus mindoensis* Peters, 1973 (IUCN SSC Amphibian Specialist Group, 2018), which was described from Mindo, Pichincha Province, Ecuador by Peters (1973), and which has been recorded from the

provinces of Cotopaxi, Pichincha, Santo Domingo de los Tsáchilas, and Esmeraldas, with all locations situated on the western slopes of the Andes between 500 and 2200 m in elevation (Lötters, 1996; IUCN SSC Amphibian Specialist Group, 2018). Arteaga et al. (2013) mentioned that the species was absent from suitable habitats in Mindo, its type locality. Individuals of *A. mindoensis* were last seen alive on 7 May 1989 between Mindo and Nanegalito, Pichincha Province, as reported by Coloma et al. (2016a). The species was considered as possibly extinct by Coloma et al. (2016a).

On 11 August 2019 at 21:30 h, CBA, MC, and EO, observed a juvenile *A. mindoensis* with snout–vent length (SVL) of ca. 12 mm resting at night on a leaf about 40 cm above ground (Fig. 1A), on the lower edge of a narrow path next to a creek in cloud forest, 13 km from Mindo (exact locality withheld to protect the population). The area is part of a private reserve, and access is restricted. After notifying AA and JV about the discovery, we organized a second visit to the creek. Searches during the second visit resulted in the discovery of another juvenile of the same size as the first, on the right side of the same creek (upstream) and also resting in a sleeping position. During further expeditions to establish population parameters, JV encountered five additional individuals, including three juveniles (e.g., Fig. 1B) and two adult males (e.g., Fig. 1C, D).

Atelopus mindoensis was described by Peters (1973) based on a combination of characteristics including size (SVL in males 19–22 mm, in females 27–29 mm), the first finger hidden by webbing, dorsal colouration lime to dark green with reddish spots and/or reddish reticulations, colour on the flanks with a reddish lateral stripe outlined by white, ventral surfaces immaculate yellowish white (Peters, 1973; Arteaga et al., 2013). The only other *Atelopus* in the Mindo area is *A. longirostris*, which is easily distinguished from *A. mindoensis* by its larger size, dark brown colouration with irregular yellow spots, a glandular elongate nose, and free digits on the hand.

¹ Doc Frog Expeditions/CRWild, 60504, Bahía Ballena, Uvita, Costa Rica.

² Department of Biology, University of New Brunswick, 10 Bailey Drive, Fredericton, New Brunswick E3B 5A3, Canada.

³ Tropical Herping, Edificio Argentina Plaza, Oficina 204, Avenida 6 de Diciembre, E8-48 y Juan Severino, Quito 170518, Ecuador.

⁴ Ecuador Reptile Adventures, Via Nambillo, Mindo, Ecuador.

⁵ Department of Vertebrate Zoology, Zoologisches Forschungsmuseum Alexander Koenig, Adenauerallee 160, 53113 Bonn, Germany; and Department of Biology, Victor Valley College, 18422 Bear Valley Road, Victorville, California 92395, USA.

* Corresponding author: alejandro@tropicalherping.com

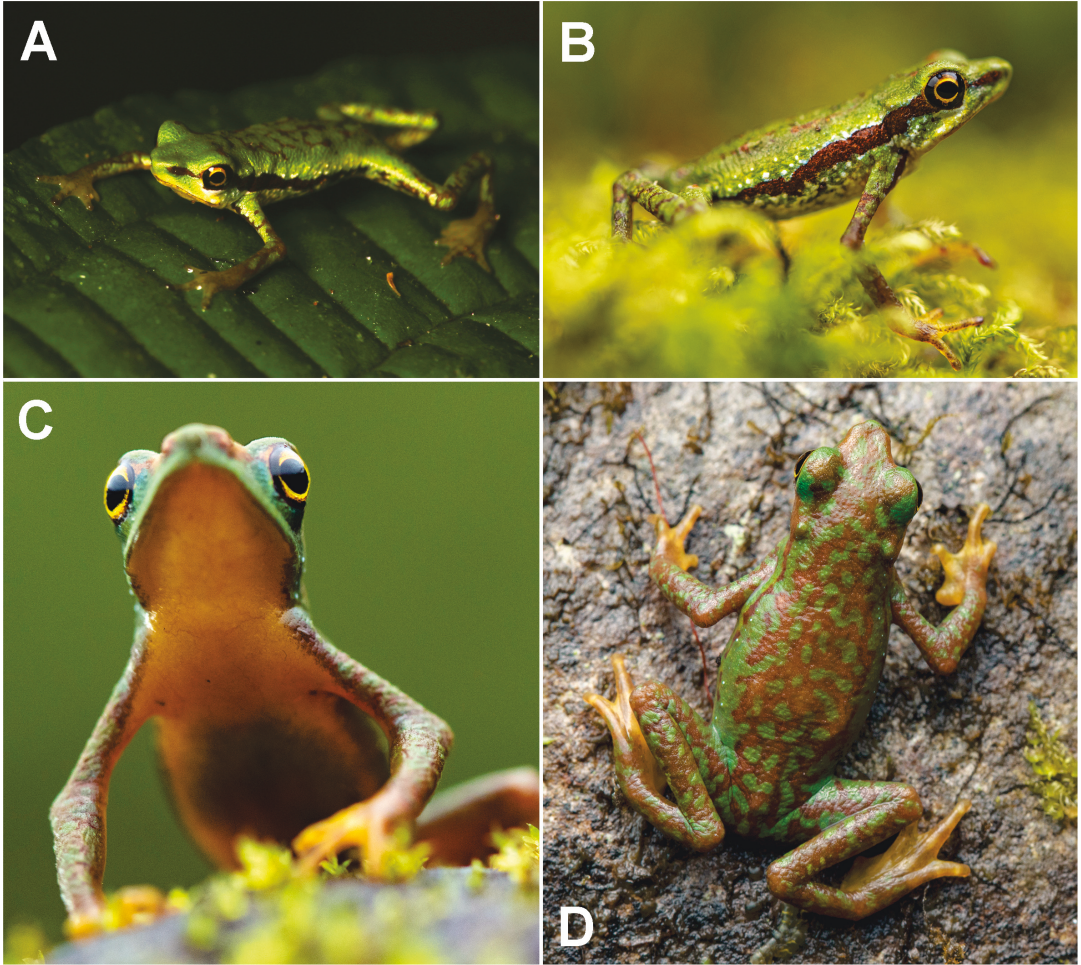


Figure 1. (A) The first individual of *Atelopus mindoensis* seen in the wild since 1989, a juvenile (SVL ca. 12 mm) photographed in situ. (B) Young *A. mindoensis* observed in mossy habitat by day. (C) Adult male *A. mindoensis* in frontal view, showing the ventral colouration. (D) Cryptic dorsal patterning seen in *A. mindoensis*, here displayed by the individual as in (C). Photos by Eric Osterman (A), Melissa Costales (B), and Jose Vieira (C, D).

Concerns and future research

Luis A. Coloma (Centro Jambatu, Quito, Ecuador) examined histological sections of skin of two toadlets for the presence of *Batrachochytrium dendrobatidis* (Bd) following the protocol of Borteiro *et al.* (2019). There was no sign of infection with Bd. The rediscovery of this species follows a trend of rediscoveries for several *Atelopus* species after decades of having been presumed lost, including *A. cruciger* in northern Venezuela in 2003 (Lampo *et al.*, 2011), *A. mucubajensis* in the Venezuelan Andes in 2004 (Barrio-Amorós, 2004), *A. varius* in Costa Rica (Barrio-Amorós and Abarca,

2016), *A. bomolochos* in southern Ecuador in 2015 (Coloma *et al.*, 2016b), *A. ignescens* in northern Ecuador in 2016 (Coloma and Quiguango-Ubillús, 2016), *A. longirostris* in northwestern Ecuador in 2017 (Coloma and Quiguango-Ubillús, 2019), *A. arsyecue* in the Sierra Nevada de Santa Marta, Colombia in 2019 (Global Wildlife Conservation, 2019), and *A. tricolor* in Bolivia (Pacheco, 2020).

As Lötters *et al.* (2005) already pointed out, the rediscoveries of new *Atelopus* populations can be interpreted in different ways. (1) It is possible that increased search efforts, due to the popularity, beauty, and well-known conservation problems of this genus

along with the existence of a multitude of interested parties (e.g., NGOs, students, amateur and professional herpetologists), leads to broader and more intensive searches and therefore new populations are being found. (2) The survival and recovery of harlequin toads after *Bd*-induced extirpations (Lips et al., 2006) lead to the re-establishment of small populations. These may include survivors which may still test positive for *Bd*, but which may not be sick or at risk of dying. (3) Populations may respond to changed and somehow favourable environmental conditions. It is possible that favourable conditions in many areas can lead to population recovery (an empty niche can be quickly filled by a few generations of harlequin toads).

For our rediscovery of *Atelopus mindoensis*, our finding of five juveniles indicates that the population is reproducing. There remains a probability that some of these individuals may be infected with *Bd* but present no symptoms, and even though the two juveniles tested negative for *Bd*, any additionally found individuals should be tested. Prevalence of *Bd* in other (lowland) populations of *Atelopus* has been mentioned (Barrio-Amorós and Abarca, 2016), but with no apparent negative effect on the population.

Our discovery of a single and unique population of *Atelopus mindoensis* should now lead to (1) a monitoring program for this population, (2) a more intense search in close and similar creeks throughout the historic distribution of the species, (3) establishment of *ex situ* colonies, if population status and local conditions allow for this possibility, and (4) education of local human inhabitants so that citizen science projects can assure the survival of this amazing species.

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