New occurrences and habitat description of southern Ecuador endemic frog

Atelopus exiguus (Anura: Bufonidae) from a conservation hotspot in the high Andes

Nuevas ocurrencias y descripción del hábitat de la rana endémica del sur de Ecuador

Atelopus exiguus (Anura: Bufonidae) en un punto crítico de conservación en los altos Andes

Abstract

Atelopus species are classified as a priority taxon for monitoring and conservation, of these A. exiguis is endemic to southern Ecuador and is classified as critically endangered, however, within its known geographic range, little attention has been given to identifying new localities particularly across the páramo ecosystem (> 3500 m a.s.l.). Therefore, in the páramo landscape of Macizo del Cajas Biosphere Reserve, a conservation hotspot, we intensively searched for A. exiguis across 15 localities (elevation range: 3550 – 3800 m a.s.l.). In one year of monitoring (2020 – 2021), we recorded four individuals of A. exiguis (two were tadpoles) in two localities. The localities are characterized by a higher proportion of páramo grassland in association with shrubby páramo as well as cushion páramo; this riparian habitat is related to relatively good water quality (according to Andean Biotic Index), relatively low water temperatures and relatively low water flow. Our findings, accompanied by a detailed monitoring protocol, suggest habitat requirements for A. exiguis. Further intensive surveys beyond the limits of protected areas of Azuay province, especially across the páramos, is emerging as an urgent step to improve conservation decisions.

Keywords

Macizo del Cajas; monitoring; endangered frogs; páramo ecosystem; water quality; conservation.

Palabras clave

Macizo del Cajas; monitoreo; ranas amenazadas; ecosistema de páramo; calidad del agua; conservación.
Introduction

The human modifications of ecosystems increasingly confine the biodiversity to landscapes with a mosaic of altered habitats (Foley et al. 2005). Particularly, in zones with high levels of species richness, endemism and concentrations of threatened species, biodiversity is more sensitive to human-induced changes to natural habitats (Sala et al. 2000). For instance, endemic frogs, such as species of Atelopus (endemic to the Neotropical region) have been greater predicted extinction risk as a consequence of global climatic change as well as disease such as the pathogenic chytrid fungus (Pounds et al. 2006, Roach et al. 2020, Urgiles et al. 2021). Atelopus exiguis is a critically endangered endemic (Ortega-Andrade et al. 2021) found in both páramo grassland and montane forest in only a few highland localities (elevation range: 3000 – 4000 m a.s.l.) of the Macizo del Cajas Biosphere Reserve (MCB) in the western Andean cordillera of Azuay province, southern Ecuador (Ron et al. 2018). The type locality of A. exiguis is Zurucuchu valley (2°50'34.8" S, 79°8'45.6" W; 3150 m a.s.l.) located in the Cajas National Park (CNP); additional localities have been reported beyond to the limits of another protected area south of CNP, Quimsacocha National Recreation Area (ARQ), near to Tres Lagunas (3°2'29.58" S, 79°12'56.41"; 3760 m a.s.l.) and Zhurucay (3°4'55.20" S, 79°13'59.63" W, 3675 m a.s.l.) for example (Ron et al. 2018, Coloma et al. 2000). Within respect to the known geographic range, little attention has been given to identifying new localities in addition to the historical records – e.g., Mazán Reserve, CNP (Maldonado 2010), given that Atelopus species are a priority taxon to monitor and conserve (Roach et al. 2020). Therefore, it is crucial to publish new occurrences along with detailed habitat descriptions of A. exiguis to update knowledge and to identify localities of interest for conservation.

Material and methods

Within the current known geographic range of A. exiguis, particularly in the páramo habitats (> 3500 m a.s.l.) of MCB (Fig. 1), southern Ecuador, we performed intensive surveys for the species across 15 localities (elevation range: 3550 – 3800 m a.s.l.) between September 2020 and August 2021. The localities are within the core area of MCB (2°55'25" S, 79°21'57" W), including páramos inside of ARQ and its buffer páramo-areas (within a radius of ~10 km). The localities were selected based on similarities in habitat to areas where past records in the study area were found (Fig. 1). In each locality, we installed a transect along the banks of streams and small rivers. Each transect was 150 m in length and 50 m in width (total area = 7500 m²). We monitored all substrates, including moving rocks and logs inside the water body as well as searches in bunch-grass species of Chalamagrostis (páramo grassland habitat), cushion plants such as Plantago rigidá and Oreobus ecuadorensis (cushion páramo) and shrubs plants such as Monticula, Hypericum and Valeriana species (shrubby páramo) as principal riparian vegetation. Each locality was surveyed once per month for a minimum of three hours, always during the day due to the species’ diurnal habits (9:00 – 17:00 h). All surveys were performed by at least two observers. All individuals recorded were identified and photographed in situ. No individuals were collected (not authorized by the Ecuadorian deputy of environment). For species identification, we used the descriptions of Coloma et al. (2000) and Ron et al. (2018). Individuals were recognized as A. exiguis by their relatively small size, dark brown dorsum and flanks with yellowish-green spots, black irises, poorly developed palmar tubercles, and snout pointed from above; while the tadpoles were recognized by the elongate-ovoid body, the greatest width at the posterior part of body, body slightly constricted at eye level, robust caudal musculature, and translucent marks posterior to eyes (Fig. 1). In addition, we performed aquatic macroinvertebrate surveys to estimate the biological water quality (Andean Biotic Index [ABI] Rios-Touma et al. 2014) and therefore habitat requirements of the species. We followed the macroinvertebrate monitoring protocol developed for the study area (for more details see Jiménez et al. [2021]).

Results

In one year of monitoring, we only recorded A. exiguis in two localities (Fig. 1). In total, we recorded four individuals (Fig. 2). On 11 June 2020, in the locality of...
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Bermejos (3°00′32.16″ S, 79°13′51.25″ W; 3724 m a.s.l.), we recorded a frog (Fig 2A-C) as well as one tadpole (Fig 2E-F); the individuals were found between rocks, partially covered by the water flow, near to the bank of a stream which is part of headwaters of Bermejos hydrological system. In the same locality, on 20 November 2020, we photographed a frog (Fig 2D), the individual was recorded ~10 m from the banks of the stream in cushion páramo. Finally, on 1 December 2020, in Colloancay (3°04′03.77″ S, 79°12′12.33″ W; 3572 m a.s.l.), we recorded a tadpole (Fig 2G-H) in the muddy-rocky bottom of the stream that is part of the headwaters of Portete hydrological system. All tadpoles were found opportunistically during the macroinvertebrate surveys.

The locality of Bermejos is characterized as a habitat dominated by páramo grassland (50%) in association with shrubby páramo (20%) as well as cushion páramo (20%) and very good (ABI [Nov.] = 98). The locality of Colloancay is a wetland dominated by páramo grassland (55%) with a lower proportion of shrubby páramo (20%) as well as cushion páramo (5%), the final 20% represents the water body; water flow was lower throughout the year but more consistent (min [Oct.] = 0.1 m$^3$ s$^{-1}$, max [Abr.] = 0.9 m$^3$ s$^{-1}$) with relatively small temperature variation (min [Nov.] = 9.8°C, max [Dec.] = 12.7°C, average = 11.5°C) and water quality, at the moment of the record was estimated to be between medium (ABI [June] = 57) and very good (ABI [Nov.] = 98). Our results indicate that the microhabitat conditions of A. exiguus across the study area (Fig 1), no record is accompanied by a formal protocol or habitat descriptions. Thus, our findings demonstrate that in addition to montane forest habitats, páramo habitats are important. Particularly, riparian vegetation in the form of open and semi-open páramo (elevation range: 3500 – 3750 m) in combination with slower moving streams with relatively good water quality (according to ABI) and low temperature water is suitable habitat.

An important factor in Atelopus species extinctions globally is the increasing presence of a pathogenic chytrid fungus linked to global climate change (Pounds et al. 2006). The optimum growth of this pathogenic fungus is predicted in ranges from 17 to 25°C (Pounds et al. 2006). The optimum growth of this pathogenic fungus is predicted in ranges from 17 to 25°C (Pounds et al. 2006). Our results indicate that the microhabitat conditions of A. exiguus across the study area are less favourable for the development of this fungus as the water temperatures were < 13.1°C. However, close to Bermejos, Urgiles et al. (2021) reported the presence of chytrid fungus on this species extinctions globally is the increasing presence of a pathogenic chytrid fungus linked to global climate change (Pounds et al. 2006). The optimum growth of this pathogenic fungus is predicted in ranges from 17 to 25°C (Pounds et al. 2006). Our results indicate that the microhabitat conditions of A. exiguus across the study area are less favourable for the development of this fungus as the water temperatures were < 13.1°C. However, close to Bermejos, Urgiles et al. (2021) reported the presence of chytrid fungus on A. exiguus, southern Ecuador endemic frog: New occurrences and habitat description in a conservation hotspot from the high Andes

Discussions

Our findings are the first record for ARQ (i.e., Bermejos) as well as indicating that there are indeed localities beyond the limits of the protected areas with suitable habitat for A. exiguus. More importantly, as far as we know, our results are the first approximation towards a habitat description for this species in the páramo ecosystem.

Before our study, one of the most complete monitoring efforts for A. exiguus came from Maldonado (2010). The study was carried out in the montane forest habitats of Mazán Reserve (3100 m a.s.l) and recorded 14 individuals (seven adult-males, one adult-female and six sub-adults). Maldonado (2010) provided a very fine description of montane habitat, including humid pastures in association with woody shrubs as well as less proportion of trees always near to the banks (~ 2 m) of small tributaries of the Mazán river, with temperature range from 11 to 14.2°C. This study conclude that Mazán Reserve is one of the most suitable habitats for A. exiguus.

However, despite several previous records of A. exiguus across the study area (Fig 1), no record is accompanied by a formal protocol or habitat descriptions. Thus, our findings demonstrate that in addition to montane forest habitats, páramo habitats are important. Particularly, riparian vegetation in the form of open and semi-open páramo (elevation range: 3500 – 3750 m) in combination with slower moving streams with relatively good water quality (according to ABI) and low temperature water is suitable habitat.

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**Literature cited**


Jiménez R, Barnuevo E, Timbe B, & Astudillo PX. 2021. The use of gremios tróficos en macroinvertebrados acuáticos como herramienta de monitoreo en los Altos Andes de Azuay province, focused within the páramos, are emerging as urgent steps to improve conservation decisions for threatened species such as Andean frogs belonging to the *A. bomolochos* group such as *A. exigus* and *A. nanay*.

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**Conflict de intereses / Competing interests:**

The authors declare no conflict of interest.

**Role de los autores / Authors Roles:**

PA: Conceptualización, Metodología, Investigación, Recursos, Escritura-Preparación del borrador original, Supervisión, Adquisición de fondos, Administración de proyecto, Redacción-revisión y edición.

RJ: Conceptualización, Metodología, Investigación, Recursos, Escritura-Preparación del borrador original, Supervisión, Adquisición de fondos, Administración de proyecto.

DS: Conceptualización, Metodología, Investigación, Recursos, Escritura-Preparación del borrador original, Supervisión, Adquisición de fondos, Administración de proyecto.

BT: Conceptualización, Metodología, Investigación, Recursos, Escritura-Preparación del borrador original, Supervisión, Adquisición de fondos, Administración de proyecto.

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**Aspectos éticos / legales; Ethics / legals:**

Authors declare that they did not violate or omit ethical or legal norms in this research. All activities were conducted under the permit number MAAE-ARSFC-2021-1069 issued by the Environmental and Water Ministry of Ecuador and therefore no individuals were collected. All individuals were photographed in the field.