

Predation by invasive rainbow trout on the critically endangered Pehuenche Spiny-chest Frog



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Ethical Statement

The care and use of experimental animals complied with CICUAE animal welfare laws, guidelines, and policies as approved by the Dirección de Recursos Naturales Renovables, Mendoza, Argentina (Res. 04/2018 and RESOL-2018-257-E-GDEMZA-DRNR#SAYOT).

Abstract

Joint first and/or senior authorship

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The Pehuenche Spiny-chest Frog *Alsodes pehuenche* is an endemic species from the Andes of Argentina and Chile and is considered to be Critically Endangered. Its population has been declining over the last ten years, principally as consequence of the paving of a road that crosses the streams the frog inhabits. Until recently, exotic fish species had not been recorded in these streams. Here, we document the presence of rainbow trout (*Oncorhynchus mykiss*) in one of these streams and predation on the endangered frog species.

Keywords: Biological invasions, Southern Andes, Pehuenche Frog, Wetlands

The Pehuenche Spiny-chest Frog (*Alsodes pehuenche* Cei, 1976) (Anura: Alsodidae) is a micro-endemic frog that inhabits in a small area near the border between Argentina and Chile (Pehuenche Valley, Mendoza province, Argentina, and subsidiary streams of the Maule lake, Maule Region, Chile, 2000–2500 masl; Corbalán et al. 2010; Correa et al., 2013, 2018). It has a very specific habitat and lives only in small streams and wetlands without aquatic frog predators. Its current distribution is extremely limited, around 32 km², which is not part of any protected area (IUCN, 2019).

The *A. pehuenche* population has been declining over the last ten years. The most serious and most frequently recorded threat is a decline in habitat quality and fragmentation due to a road paving project, which diverted some streams. This is the main reason that the IUCN (2019) categorizes the species as Critically Endangered. Its complex life history, which includes a long larval period and an almost exclusively aquatic adult life, makes it highly sensitive to environmental stressors (Corbalán et al., 2008, 2014). Currently, new stressors are increasing the level of threat to these frogs. The building of a high curb along a two-kilometer stretch of road where streams cross has led to a significant population decrease. The 6-cm long frogs cannot go over the curb or cross the road and many die dehydrated on the concrete (V. Corbalán and G. Debandi, personal observation;

IUCN, 2019). Some wetlands and streams where the frogs live have shrunk or dried up due to trampling by livestock (Corbalán et al., 2010; IUCN, 2019), climate change (Bianchi et al., 2017), and tectonic movements which have redirected underground water flow and changed where water reaches the surface and mountain streams begin (Sagripanti et al., 2015). Chytrid fungus was found on frog skin (Ghirardi et al., 2014), but its effect is poorly known. Water contamination and the recent building of a ski slope near the streams, which are covered by snow in the winter, could also have a negative impact on frog populations and should be evaluated (Corbalán et al., 2010; V. Corbalán and A. Zarco, personal observation).

On the Argentinean side of the border, the small streams *A. pehuenche* inhabits are subsidiaries of the more turbulent Pehuenche Stream, where the frog species has not been recorded. Here, rainbow trout (*Oncorhynchus mikyss*; Walbaum, 1792) has been illegally released in recent years, perhaps because fly fishing is an increasingly popular activity. This salmonid is a voracious predator and considered to be one of the hundred most harmful invasive exotic species in the world (Global Invasive Species Database, 2020). In Argentina, there are many examples of the adverse effects of exotic fish on native amphibian and endemic fish (Cuello et al. 2009; Ortubay et al. 2006; Quiroga et al. 2017; Velasco et al. 2018). Corbalán et al. (2010) hypothesized that rainbow trout in the Pehuenche stream could be a conservation problem for *A. pehuenche*, since this might prevent the frogs from moving to small streams and ponds downstream in the Pehuenche Valley. No trout of any kind was recorded in streams the frogs inhabit in surveys between 2007 and 2019 (V. Corbalán, personal observation). However, earlier this year, we documented *O. mikyss* moving from the Pehuenche stream up a minor stream and preying on *A. pehuenche*.

On 9 January 2020, during a census of *A. pehuenche* adults and larvae in four streams, we observed four *O. mikyss* fish in one stream (35°58'30.8" S, 70°23'15.1"W, 2472 masl, WGS84). The stream is 1000 m long and crossed by highway 155 at its midpoint. This stream flows into the Pehuenche Stream (Figure 1) which, at this time, showed a very low flow compared to previous years. Rainbow trout were found in four different points along the last section of the

stream before its confluence with the Pehuenche Stream. The trout farthest from the confluence was 100 m upstream. One of these fish, 17.5 cm long, was collected and dissected in the laboratory under a stereo microscope. The stomach contained an adult Trichoptera, many gammaridean amphipods, and two partially-digested amphibians (Figure 2). In one of these, all four legs were developed but the tail remained. We confirmed that both were *A. pehuenche* because they had interdigital membranes on the hind legs; the only sympatric amphibian, the large Four-eyed Frog *Pleurodema bufoninum* Bell 1843, does not have interdigital membranes.

In the frog census, we found an average of 3.5 adults and 89 tadpoles per 100 m along the stream, but we did not find any adults or tadpoles in the final 100 m before the confluence, where trout were observed. Previously, we had recorded both adults and tadpoles in this section of the stream. Since there are no other stressors here, we attribute the absence of adults and tadpoles to trout predation.

Our findings identify an additional factor in the decline of populations of this frog species. Although the density of trout seems low and they were observed in a small area, frog predation highlights the problems caused by exotic rainbow trout. There is nothing to limit an increase in trout density or the colonization of streams that *A. pehuenche* inhabits. The synergic effects of introducing an exotic predator with existing habitat stressors is unknown, but it could be fatal to the remaining frog populations. Since the available habitat for this species is shrinking, urgent action is necessary to prevent trout from entering the few streams where this frog lives. Moreover, legislation is needed to discourage trout fishing in the Andes.

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Contributions

Z. participated in the field trip, captured the trout, and prepared the first version of the manuscript.

V.C. obtained funding, coordinated activities, participated in the field trip, improved the text, and prepared the Figures.

G.D. obtained funding, dissected the trout under a stereo microscope, identified the stomach contents, and improved the text.

Significance statements

The Pehuenche Spiny-chest Frog *Alsodes pehuenche* is an endemic species from the Andes of Argentina and Chile that is Critically Endangered due to the paving of the road that crosses the streams it inhabits. Here, we report for first time the presence of rainbow trout in these streams and document frog predation.

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Figure captions

Figure 1. Habitat of the frog *Alsodes pehuenche* invaded by trouts A) sector of the stream where trouts were observed and captured, B) site where the small stream flows into the Pehuenche Stream.

Figure 2. Stomach content of the Rainbow Trout *Oncorhynchus mykiss* where parts of *Alsodes pehuenche*' frogs can be observed. A) individual with rest of tail, B) detail of hind-leg.



