Short Communication

Partnerships between private landowners and conservationists to protect one of the most evolutionarily distinct amphibians

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Abstract Wildlife conservation on private land is an important and growing approach to protecting biodiversity and can help contribute to the Global Biodiversity Framework's 30 by 30 target. In 2018, a Chilean non-profit conservation organisation launched a pioneering land conservation programme aiming to build long-term partnerships with private landowners to protect critical habitat for threatened amphibians in Chilean Patagonia. Here, we describe a new locality record of the microendemic and Endangered Barrio's frog (*Insuetophrynus acarpicus*) found at a site that joined this programme in 2020. The Barrio's frog is ranked No. 10 in the list of evolutionary distinct, globally endangered amphibians. Unfortunately, as evidenced by our systematic literature search, most aspects of the species' natural history and ecology remain unknown, limiting our ability to provide actionable science to inform its conservation. The newly described Barrio's frog population represents the eighth known locality of this species and one of only three occurring within a protected area. Habitat quality assessments indicated optimal conditions for most of the measured habitat parameters in the high-gradient stream where the species was found. This case study highlights that long-term partnerships between private landowners and conservationists can be used as an effective tool to protect the habitat of highly threatened amphibians.

Keywords amphibian conservation; EDGE species; land conservation; Patagonia; Rhinodermatidae

Supplementary material for this article can be found at

Private land conservation is an important and growing approach to protecting biodiversity and can help contribute to the Global Biodiversity Framework's 30 by 30 target (Cortés Capano et al., 2019; Dinerstein et al., 2019). In Chile, private initiatives are protecting at least 16,692 km^2 of land (Moya Ramírez et al., 2016), covering key terrestrial ecosystems that are not protected by the Chilean system of public protected areas (Pliscoff & Fuentes-Castillo, 2011). Taking advantage of this momentum, in 2018 the NGO Ranita de Darwin designed and launched a pioneering land conservation programme aiming to build long-term partnerships with private landowners to protect critical habitat for threatened amphibians in Chilean Patagonia (Azat et al., 2021). Here, we describe a new locality record of the microendemic and Endangered Barrio's frog (*Insuetophrynus acarpicus*) found in the Refugio de Ranitas Aldea del Viento protected area, a 7-ha property that joined the land conservation programme in 2020 (Plate 1a). This represents the eighth known locality of this species and one of only three occurring within a protected area (Fig. 1).

The Barrio's frog, along with the northern and southern Darwin's frogs (*Rhinoderma rufum* and *R. darwinii*), are the only known members of the family Rhinodermatidae, a 70-million-year-old group of neotropical frogs considered to be the oldest known hyloids, a species-rich clade encompassing 54% of the world's extant anuran species (Feng et al., 2017). Darwin's frogs are highly imperilled, particularly the northern Darwin's frog, a species last seen over 40 years ago and today categorized as Critically Endangered (Possible Extinct) by the IUCN Red List of Threatened Species. This situation highlights the importance of the Barrio's frog as one of the last representatives of Rhinodermatidae. The Barrio's frog is among the top 100 most evolutionarily distinct amphibian species (Jetz & Pyron, 2018) and is ranked No. 10 in the EDGE ranking of amphibians (a framework that identifies the world's most evolutionarily distinct and globally endangered species; Safi et al., 2013). This Chilean microendemic species is categorized as Endangered due to a small geographic distribution (1,323 km^2; Fig. 1), highly isolated populations, and a continuing decline in the extent and quality of its habitat (IUCN SSC Amphibian Specialist Group, 2018). Unfortunately, most aspects of the species natural history and ecology remain unknown (Fig. 2 and Supplementary Material 1), limiting our capability to implement evidence-based conservation actions.

In April 2022, we identified a Barrio's frog population located in the Refugio de Ranitas Aldea del Viento protected area, Los Pellines, Chile. This population, which is 18 km away from the nearest known population situated in Chanchan, fills a gap in the distribution of Barrio's frogs along the coast of Valdivia (Fig. 1). Five Barrio's frog individuals were found along a 200-m section located at the source of one of two high-gradient streams present in the private protected area (Plate 1b-d). Individuals were mostly found under small boulders within the stream. Habitat quality assessments

following the protocol by Barbour et al. (1999) indicated optimal conditions for most of the measured habitat parameters at both streams present in the area, although habitat quality was slightly higher in the stream where Barrio's frogs were found (Supplementary Table 1). Briefly, these streams were characterised by abundant epifaunal substrate, low embeddedness and sediment deposition, minimal amount of channel substrate exposition, stable banks, absence of channelisation, frequent riffles and pools, and the riparian zone was covered by native vegetation. Our results agree with previous findings from a locality near Mehuín showing a positive relationship between Barrio's frog occurrence and stream habitat quality measured with the same habitat assessment protocol (I. Vásquez & A. Valenzuela-Sánchez, unpublished data). More generally, our findings are consistent with previous field observations indicating this species is a stream-breeding amphibian with individuals generally found near or in water (Méndez et al., 2006; Contreras et al., 2020; see also references in Supplementary Material 1). Motivated by the discovery of this population, the landowner (who is also a co-author in this article) is considering new ways for increasing the level of protection given to the species in the area (e.g., upgrading the voluntary land conservation agreement with NGO Ranita de Darwin by signing a conservation easement under the framework of the Derecho Real de Conservación law).

This case study highlights that long-term partnerships between private landowners and conservationists can be used as an effective tool for protecting the habitat of highly threatened amphibians. This is particularly relevant in the case of evolutionarily distinct amphibian species, which are disproportionally susceptible to local extinction due to habitat loss (Greenberg et al., 2018). The voluntary land conservation agreement between a landowner and NGO Ranita de Darwin defines clear conservation targets (e.g., native amphibians, including Barrio's frogs) and conservation goals (e.g., protect the habitat of native amphibians and control threats to ensure self-sustaining amphibian populations). It also sets a list of strategies to achieve these goals, including a broad array of conservation actions, such as habitat protection and restoration, management of invasive species, and promotion of conservation-focused research, and a monitoring plan to evaluate success and allow adaptation. An important priority in the Refugio de Ranitas Aldea del Viento protected area is to determine the presence and impact of potential threats to Barrio's frogs, especially those that could originate from surrounding lands because, to our knowledge, these areas are not managed with any conservation goal. This will allow to the better development and prioritisation of strategies to prevent or reduce threats. Identified potential direct and indirect threats to Barrio's frogs in this protected area include: 1) free-roaming cattle; 2) the fungus *Batrachochytrium dendrobatidis*; 3) pollution runoff from a road situated 200m away; 4) domestic sewage from nearby residential buildings; 5) fresh water

abstraction; 6) illegal logging; 7) increased land subdivision for residential development in nearby native forests; 8) neighbouring exotic tree plantations; and 9) climate change (Rodriguez et al., 2022).

Collaborative efforts between private landowners and conservationists have enabled the protection of critical habitat for amphibians in the USA (Kuyper, 2011; Milmoe, 2008; Symonds, 2008) and United Kingdom (Pond Conservation: The Water Habitats Trust, 2012). For success, these types of conservation initiatives need to consider the local context, including case-specific factors driving landowner participation and permanence within the programme (Selinske et al., 2014; Valenzuela-Sánchez et al., 2022). A study conducted in the northern portion of the Barrio's frog distribution found that landowners (represented mainly by subsistence farmers) would be willing to join a land conservation programme only if this resulted in direct government-related economic incentives (Vásquez & Marchant, 2021), a mechanism not yet available in Chile. In contrast, results from a semi-structured interview of people participating in the NGO Ranita de Darwin land conservation programme showed that most landowners joined the scheme primarily to fulfil their conservation values, while increasing their knowledge about amphibians was one of the most prevalent landowner expectations of signing up to the programme (Hernández, 2022). Our medium-term goal is to continue targeting this type of audience in Chilean Patagonia to incorporate additional habitat suitable for Barrio's frogs to this land conservation network.

Amphibian-focused land conservation programmes can be used not only to engage people in amphibian conservation, but also to communicate the importance of amphibians for ecosystem functioning and human well-being (Valenzuela-Sánchez et al., 2022). We argue that increasing public and stakeholder knowledge about amphibians should be a priority in amphibian conservation, as evidence demonstrates that even a modest knowledge increase can enhance people's positive attitudes and behaviours toward these animals (reviewed by Valenzuela-Sánchez et al., (2022)). Unfortunately, public knowledge about amphibians is generally poor (Valenzuela-Sánchez et al., 2022). For instance, prior to their inclusion into the land conservation programme led by NGO Ranita de Darwin most landowners had a lack of knowledge about the level of diversity and endemism of native amphibians (Hernández, 2022). Partnerships between landowners and conservationists can also be used to boost the co-production of knowledge, potentially resulting in much-needed actionable science in amphibian conservation (Valenzuela-Sánchez et al., 2022). As part of the Refugio de Ranitas Aldea del Viento monitoring plan, we will implement a long-term capture-recapture study of the Barrio's frog population present in this protected area. This study should contribute new knowledge about the demography and spatial ecology of this highly understudied species, but most importantly will help to inform species-specific conservation actions within this private protected area. Similar ecological

studies are urgently required to evaluate the population status of, and prioritise conservation efforts for, other Barrio's frog populations across the species' range.

Author contributions Study design, fieldwork: AV-S, SM, RMG, JG, RC, JG, SD-O, MN and MBZ; data analysis, writing: AV-S, with contributions from MBZ, RMG and AAC. All authors gave final approval for publication.

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Conflicts of interest SM is the owner of the Refugio de Ranitas Aldea del Viento protected area.

Ethical standards This research abided by the *Oryx* guidelines on ethical standards. This study was conducted in accordance with Chilean law under permit number 226/2021 of the Servicio Agrícola y Ganadero de Chile.

Data availability All data used in this study can be found in the main manuscript or in the supplementary material.

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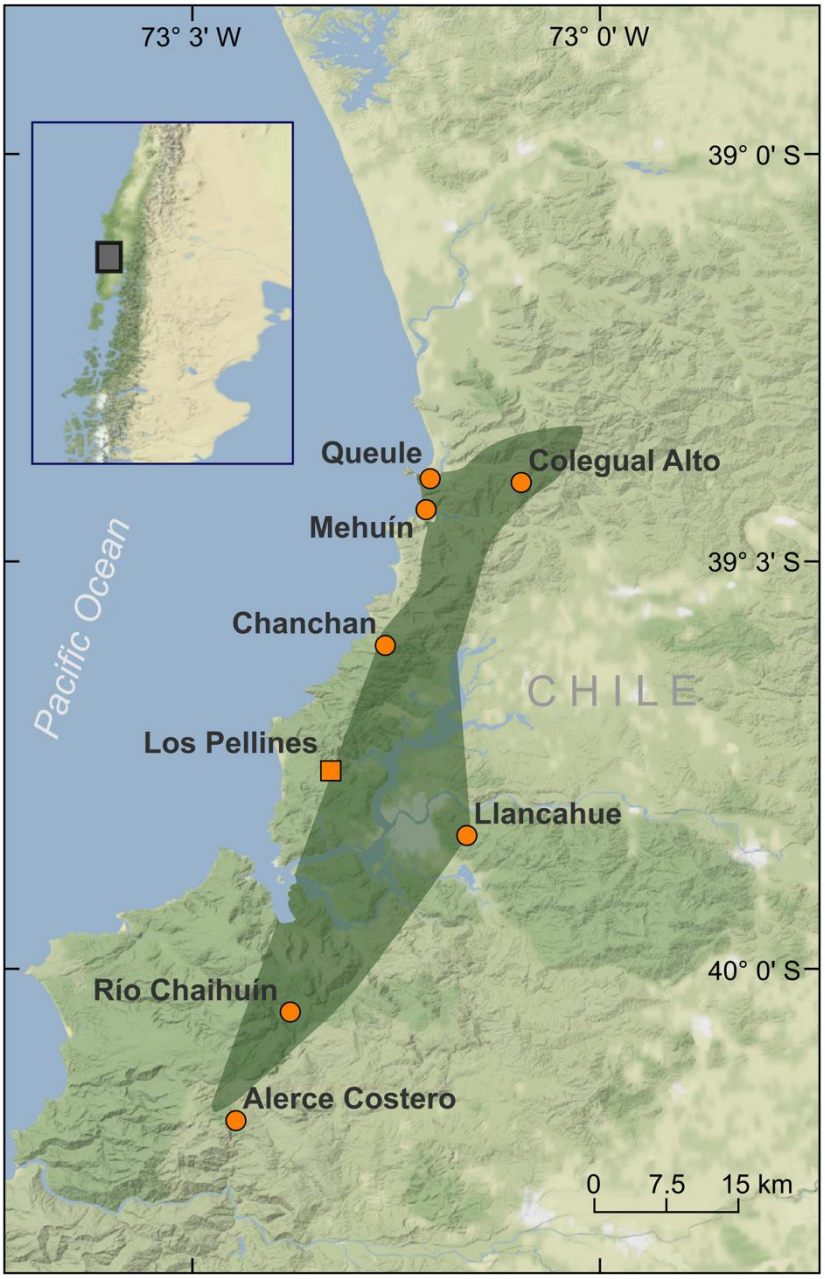

FIG. 1 Previously known localities (circles) and new locality record (square) of Barrio's frogs (*Insuetophrynus acarpicus*) in southern Chile. The shaded area represents the extent of occurrence of Barrio's frogs according to the IUCN Red List of Threatened Species (downloaded on 14th August 2023). Geographical coordinates of previously known localities were extracted from Contreras et al. (2020), except for Queule coordinates which were obtained from Méndez et al. (2006).

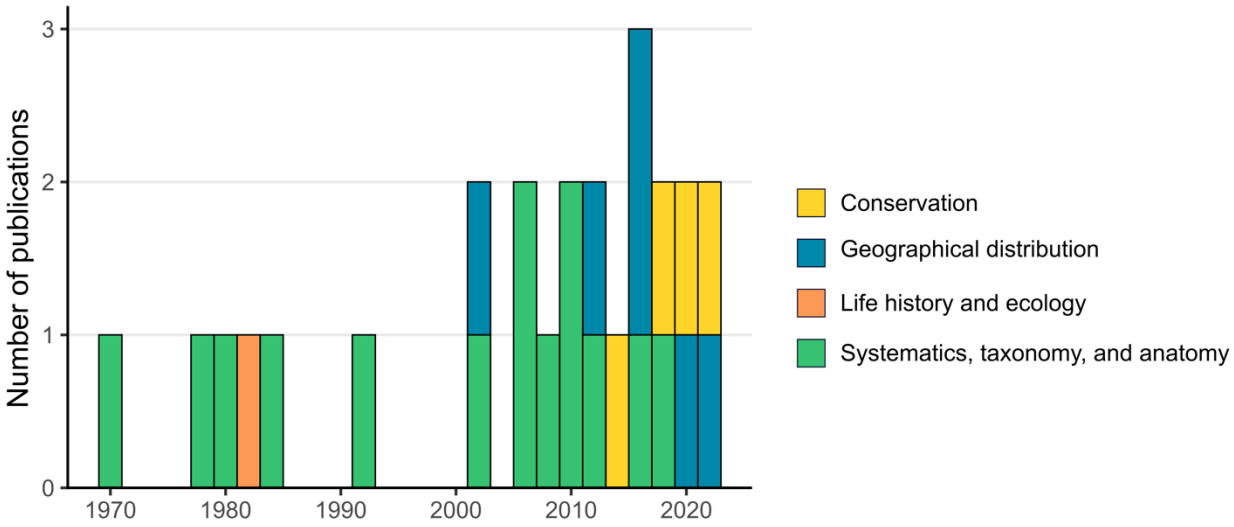

Fig. 2 Research publications about Barrio's frogs published since the description of the species in 1970. Publications were searched using Web of Science and Google Scholar with the terms "*Insuetophrynus*" OR "Barrio's frog". We excluded species checklists or reviews that mentioned the species without providing novel information or analyses. The search was performed on 7th August 2023. The full list of articles can be found in Supplementary Material 1.

PLATE 1 (a) Signing of a voluntary land conservation agreement between the landowner and NGO Ranita de Darwin and creation of the protected area Refugio de Ranitas Aldea del Viento, Los Pellines, Valdivia, Chile. (b) Adult Barrio's frog (*Insuetophrynus acarpicus*) found in this protected area. (c) A section of the high-gradient stream where the species was found.