Lost and found: the rediscovery of the lost fern species *Asplenium achalense* (Aspleniaceae) and assessment of its conservation status

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Abstract The fern of Achala *Asplenium achalense* Hieron. (Aspleniaceae), endemic to north-west and central Argentina, was formerly considered a lost species. We describe its rediscovery in August 2022 in the Yungas biogeographical province, compile a map of all historical and current records of the species, and propose an IUCN Red List status. We estimated the fern of Achala's range using the area of occupancy of the rediscovered population, calculated as 4 km² because it is located in a single 2 × 2 km grid square. The extent of occurrence cannot be calculated because only a single living population is known. These data suggest a provisional categorization of the fern of Achala as Critically Endangered based on criteria B2ab(i,ii,iii,iv,v). The species should be considered Regionally Extinct in its locus classicus in Comechingones biogeographical province. We recommend securing the conservation of the single known population (which does not lie within a conservation unit), further surveys for the species in the five protected areas where it was recorded historically, and restoration of the species in the wild. To support the latter, we are cultivating spores and gametophytes of the fern of Achala, in collaboration with colleagues from the National University of La Plata.

Keywords Argentina, Aspleniaceae, *Asplenium achalense*, biogeographical province, conservation status, fern of Achala, IUCN Red List, rediscovery

Current estimates of species extinction rates are three to four orders of magnitude greater than background extinction rates (Barnosky et al., 2011), and of the c. 160,000 species so far assessed for the IUCN Red List, 28% are considered threatened with extinction (IUCN, 2024). Additionally, there is a subset of described species that have not been seen in the wild for a long time and it is therefore unclear whether they are extinct or simply lost. Long & Rodriguez (2022, p. 481) defined a lost species as 'one not confirmed alive by photographic, audio or genetic information for over 10 years in the wild, and has no ex situ population under human care'. The Search for Lost Species, launched in 2017, is looking for plants, animals and fungi (Re:wild, 2023), with 12 of the most wanted species so far found. Although there are no ferns on the list of most wanted species, some have been rediscovered: *Jamesonia maxonii* (Lellinger) Pabón-Mora & F. González (Pteridaceae) was rediscovered in the Paramos of Colombia after being considered extinct for 5 decades (González et al., 2015), and *Anogramma ascensionis* (Hook.) Diels (Pteridaceae), endemic to Ascension Island, was rediscovered in 2009 after a similar period (Baker et al., 2014).

In Argentina, *Asplenium* L. is the most species-rich fern genus, with 38 native taxa, occurring mainly in the Neotropical area of the country, with a few species in the Andean region (Arana et al., 2020). The fern of Achala *Asplenium achalense* Hieron. was described by the German botanist Hieronymus (1896) from Pampa de Achala, Córdoba province, central Argentina. This fern is characterized by pendant pinnate fronds up to 80 cm long (Plate 1a,b). The label data of the type specimen indicates it was growing in rock crevices in grasslands at 1,200–2,000 m in the Comechingones biogeographical province, in mountainous regions of central Argentina (Arana et al., 2021a; Plate 1d). In the 20th century the species was found as an epiphyte in forests of the Yungas biogeographical province, a biodiverse area rich in species of Lauraceae and Myrtaceae (Arana et al., 2021a; Plate 1c). The Yungas is one of the centres of fern diversity in the Southern Cone of South America (Ponce & Arana, 2019; Arana & Ponce, 2021), and is an area of conservation priority because of its high species richness and endemism and its importance for biogeographical connectivity (Arana et al., 2021a).

The fern of Achala belongs to a complex of species, but Arana et al. (2022) characterized it as a well-defined taxon endemic to north-west and central Argentina. The 18 known herbarium specimens unequivocally referred to *A. achalense* were collected during the 19th and 20th centuries, the most recent in 1993 in the province of Salta (Arana et al., 2022). In c. 50 3–5 day field trips from 1999 onwards

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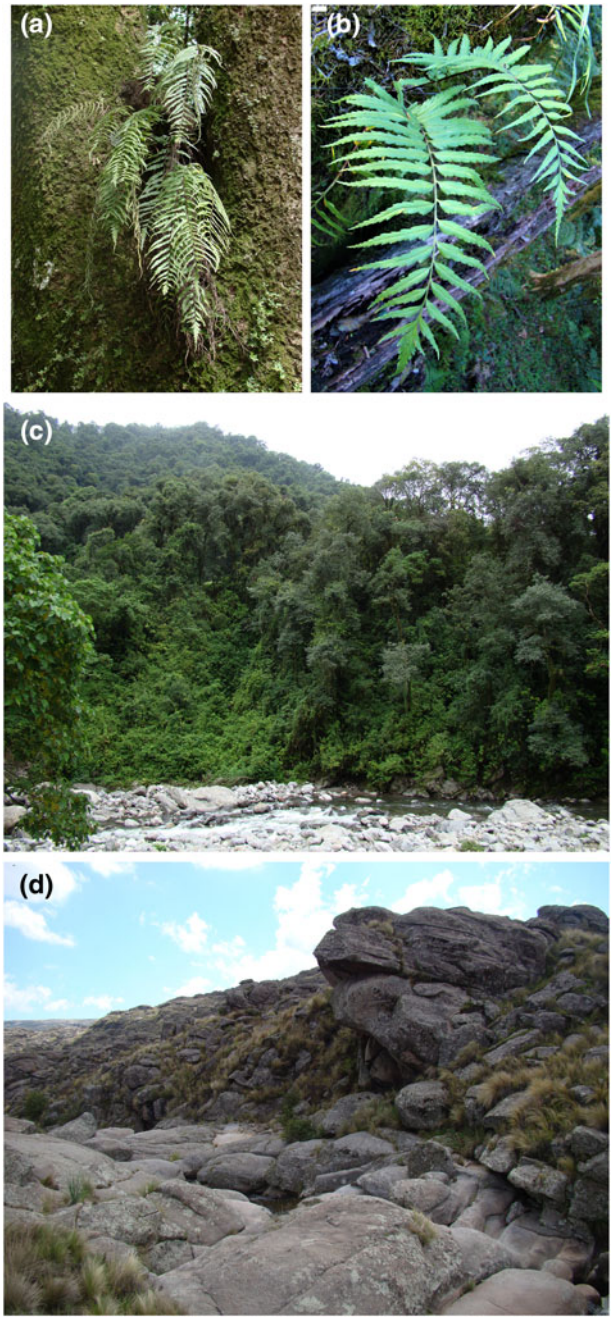

PLATE 1 (a) Epiphytic habit of the fern of Achala *Asplenium achalense*; (b) the fern's habit; (c) typical environment of the Yungas biogeographical province; (d) typical environment of the Comechingones biogeographical province.

to places potentially suitable for the fern of Achala in the Yungas and Comechingones biogeographical provinces, we did not relocate it in places where it had been collected previously or in places with microhabitats similar to the locus classicus in Pampa de Achala, and it was therefore considered a lost species (Romagnoli et al., 2023). However, in August 2022 we found a living population of the species in the Yungas (eight individuals, in different reproductive stages), growing as an epiphyte on horco molle *Blepharocalyx salicifolius* (Kunth) O. Berg (Plate 1a,b). Here we re-evaluate its status as a lost species, to support conservation action and to prevent its extinction.

We compiled a database of all known specimens (preserved and living) and published records of the species, including those summarized in Arana et al. (2022), and generated a map of all records (Fig. 1) superimposed on a map of biogeographical provinces (Arana et al., 2021a). Using GeoCAT (Bachman et al., 2011) and a 2×2 km grid as recommended in the IUCN guidelines (IUCN, 2012a), we estimated the area of occupancy (AOO) of the known population to be 4 km². We were unable to calculate the extent of occurrence as only one living population is known.

We propose that the fern of Achala should be categorized as Critically Endangered, based on criterion B2ab(i,ii,iii,iv,v); i.e. an AOO of < 10 km² (B2), a single location (a), and a continuing decline (b) in the extent of occurrence (i), area of occupancy (ii), area, extent and quality of habitat (iii), number of locations (iv), and number of mature individuals (v). Along with assessing the risk of species becoming globally extinct, it is also important to assess species at regional and national levels (IUCN, 2012b), and the fern of Achala should be considered Regionally Extinct in its locus classicus in Comechingones biogeographical province.

The rediscovered population of the fern of Achala lies centrally within its historical range, suggesting that anthropogenic pressures on the species are strongest at the periphery of its range (Channell & Lomolino, 2000). The Comechingones grasslands have been degraded by the almost annual setting of intentional fires, with the almost 40,000 ha fire in 2020 being the most extensive since 2010 (Oggero et al., 2020; Arana et al., 2021b; Mari et al., 2021). The Yungas in Argentina has lost more than 31% of its original extent as a consequence of intense anthropogenic disturbance associated with oil exploitation, extensive ranching, and agricultural and urban expansion (Malizia et al., 2012).

Securing the survival of the fern of Achala in the short term and restoring the species to the wild in the long term in an environment in which almost all habitats have been severely modified by human activities will be a challenge. Overlaying all fern of Achala records on a map of the Integral System of Protected Areas in Argentina (not shown) indicates that only five of the species' historical records were within protected areas and that the rediscovered population does not lie within a conservation unit. We recommend further surveys for the species in the protected areas where it has been recorded historically, and reintroduction of the species into optimal habitats within protected areas. To facilitate reintroduction, studies of spore germination, gametophyte development and cultivation of sporophytes are required (Ibars & Estrelles, 2012; Ballesteros &

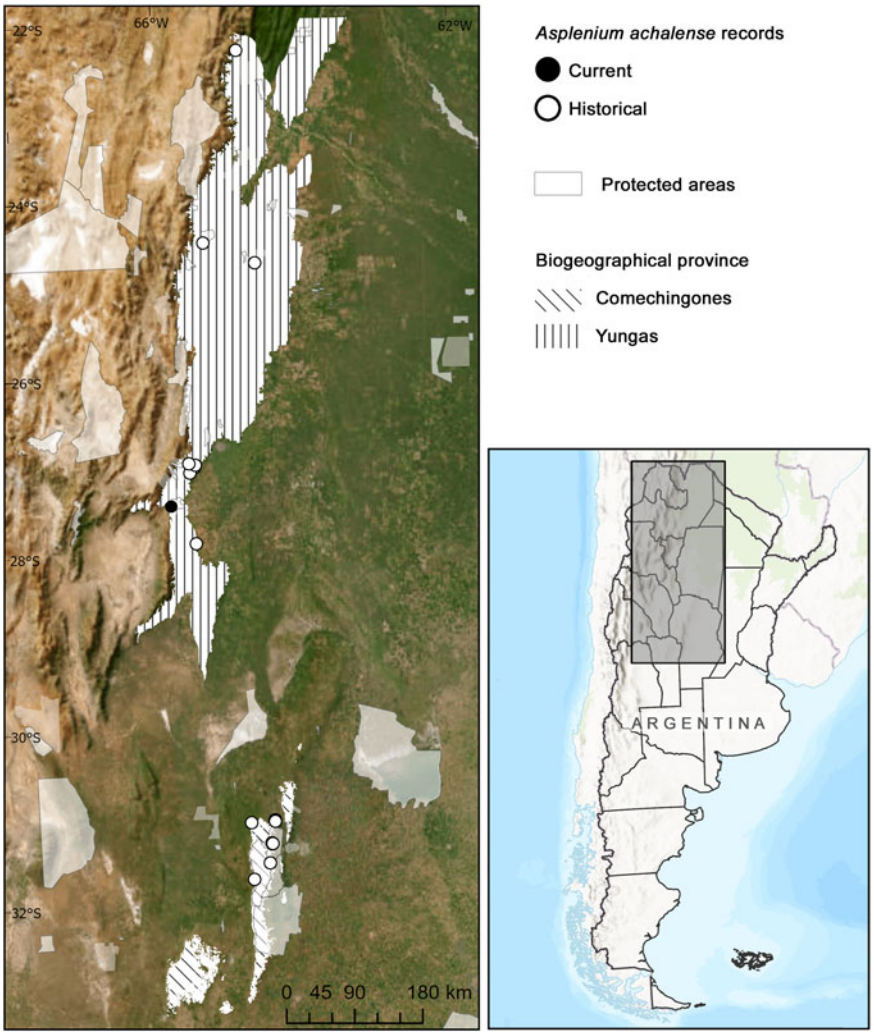

FIG. 1 The historical and current records of the fern of Achala *Asplenium achalense* in the Comechingones and Yungas biogeographical provinces in Argentina.

Pence, 2018). This is currently being carried out, in collaboration with colleagues from the National University of La Plata, to produce sporophytes that can be used to restore the species in areas where it has apparently disappeared.

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Conflicts of interest None.

Ethical standards This research abided by the *Oryx* guidelines on ethical standards.

Data availability The specimens documenting the rediscovery are deposited in herbarium RCVC, with duplicates in herbaria LIL and LP.

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