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Rediscovery of *Andinophryne olallai* Hoogmoed, 1985 (Anura, Bufonidae), an enigmatic and endangered Andean toad

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***Abstract.*—We report the rediscovery of *Andinophryne olallai*, an endangered species only known from a single specimen, collected in 1970. At the type locality, Tandayapa, Pichincha Province, numerous follow-up surveys after 1970 failed to record the species suggesting that the population is extinct. The rediscovery of *A. olallai* took place in 2012 at Río Manduriacu, Imbabura Province, Ecuador. Two surveys suggest that a healthy population of *A. olallai* survives at the site, with observations of froglets, juveniles, and adults across numerous stream systems. However, the extent of known occupancy of the population is small (<1 km²). Further data are presented to update knowledge of the distribution, ontogeny, morphology, and conservation status of the species. The population at Río Manduriacu is surrounded by logging, mining, and hydroelectric developments that could compromise its future survival. There is an urgent need to establish a monitoring program and to protect its remaining population and habitat in the region.**

Key words. *Andinophryne olallai*, rediscovery, Tandayapa Andean toad, Andinosapo de Olalla, Bufonidae, Endangered species, Ecuador

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Introduction

The small and understudied toad genus *Andinophryne* (Bufonidae) is restricted to the western slopes of the Andes in Colombia and Ecuador. Three species of *Andinophryne* have been described: *Andinophryne atelopoides* (Lynch and Ruiz-Carranza 1981), *Andinophryne colomai* (Hoogmoed 1985), and *Andinophryne olallai* (Hoogmoed 1985). Until recently, all three species were only known from five or fewer adult individuals at the type localities: *A. atelopoides* (Cauca Department, Colombia, 1980), *A. colomai* (Carchi Province, Ecuador, 1984), and *A. olallai* (Pichincha Province, Ecuador, 1970).

The paucity of information available on *Andinophryne* has led to many questions about the taxonomic and conservation status of all three species. *Andinophryne atelopoides*, the only species endemic to Colombia and only known from two specimens, was originally placed in the genus *Bufo* by Lynch and Ruiz-Carranza (1981). Four years later, following the discovery of two similar bufonid species (*A. colomai* and *A. olallai*) in northern Ecuador, and the reexamination of information presented on *B. atelopoides* by Lynch and Ruiz-Carranza (1981), Hoogmoed (1985) created the genus *Andinophryne* (Bufonidae), and placed all three species within the new genus.

Despite numerous attempts by trained scientists and over 150 search hours, subsequent visits to the type localities of *A. colomai* and *A. olallai* in Ecuador have failed to record either species (Coloma et al. 2004; Ron and Frenkel 2013). Then, in 2005, Murillo et al. (2005) reported a 160 km range extension for *A. olallai* in Río Ñambi, Department of Nariño, Colombia. This observation marked the first record of any *Andinophryne* species in more than two decades. However, as part of our recent work with *Andinophryne*, a member of our team recently examined a specimen from Río Ñambi and determined that it was not *Andinophryne olallai* but a different species (Santiago Ron, unpubl. data). This identification has been confirmed by additional fieldwork and specimens collected at Río Ñambi by Paul David Gutiérrez-Cárdenas (pers. comm.). Therefore, *A. olallai* is the rarest of all *Andinophryne* species, with the only known record being the original type specimen from Tandayapa, Pichincha Province, Ecuador in 1970.

Forty-three years after the original description of *Andinophryne olallai*, we report the rediscovery of a population of *A. olallai* from Río Manduriacu (herein Manduriacu), Imbabura Province, Ecuador. We also pro-

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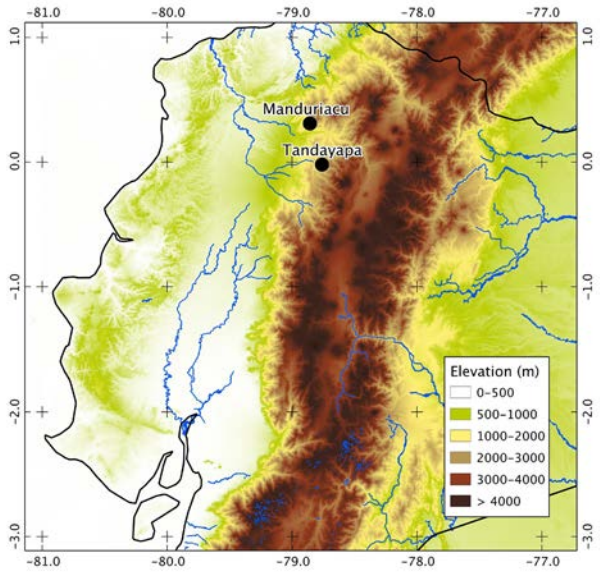

Fig. 1. Known records of *Andinophryne olallai* in northwest Ecuador; Tandayapa: Type Locality, Manduriacu: New Locality.

vide the first information on the species' natural history, geographic range, ontogeny, and conservation status, and present the first published color photos of live individuals across different age classes.

Materials and Methods

Our surveys took place in the premontane tropical forest and cloud forests of Manduriacu in NW Ecuador (1,100–1,400 m), 40 km N of the type locality of *A. olallai* and near the south border of the Cotacahi-Cayapas Ecological Reserve (Fig. 1). Surveys were conducted on 18 November 2012 (original rediscovery) and 13–15 May 2013 using Visual Encounter Surveys (VES) along stream transects between 19:00 and 01:00 h.

The objectives of the surveys were: (1) determine the population status of *A. olallai*; (2) determine the extent of its occupancy in Manduriacu; and (3) obtain information about the behavior and natural history of the species. Surveys were carried out along small rocky streams with overhanging herbaceous vegetation (Fig. 2). A total of three nights were spent surveying four stream systems neighboring the site of initial discovery (approximately 100 m between streams; < 1 km^2 area total).

Information collected in the field included: air temperature (°C), relative humidity (%), time of encounter (24 hr), perch height (cm), snout-vent length (SVL, mm), sex (when possible), and age class (froglet, juvenile, adult). Froglets (i.e., recently metamorphosed individuals) were defined as individuals with heavily patterned dorsum, lack of pronounced parotoid glands, and SVL between 10–20 mm. Juveniles were defined as individuals with faint dorsal patterning, more pronounced parotoid glands, and SVL between 20–30 mm. Adults were defined as individuals with no dorsal patterning, very pronounced parotoid glands, presence of large cream-tan colored tubercles on the flanks, and SVL above 30 mm.

Perch height for each individual was measured using a marked meter stick and SVL measurements were taken using dial calipers. Climate information was recorded using a handheld Kestrel 3500 Weather Meter. Individual toads were only handled when necessary, and always with use of latex gloves to prevent transferring pathogens such as amphibian chytrid fungus (*Batrachochytrium dendrobatidis*).

Results and Discussion

During the first survey of Manduriacu on 18 November 2012, two adult *A. olallai* were encountered perched on leaves overhanging a small running stream. Elevation of the observation site was 1,253 m, and perch heights of the individuals were 1.5 m and 2.0 m above ground. Both individuals appeared to be females, based on size, with SVL of 57 and 58 mm, however sex could not be determined with complete certainty in the field because no secondary sexual characteristics are evident in live

Table 1. Reptiles and amphibians associated with *Andinophyne olallai* at Manduriacu, Imbabura Province, Ecuador and their current (August 2013) IUCN and FaunaWebEcuador Red List status (NE – Not Evaluated, DD – Data Deficient, LC – Least Concern, NT – Near Threatened, V – Vulnerable, EN – Endangered). IUCN Red List available at: http://www.iucnredlist.org/; FaunaWebEcuador Red List available at: http://zoologia.puce.edu.ec/vertebrados/anfibios/EspeciesEstadoConservacion.aspx.

Species	Fauna Web Ecuador Red List	IUCN Red List
Caecilia guntheri	DD	DD
Centrolene peristictum	NT	V
Epipedobates darwinwallacei	EN	NE
Espadarana prosoblepon	LC	LC
Hyloscirtus alytolylax	NT	NT
Pristimantis achatinus	LC	LC
Pristimantis calcarulatus	LC	V
Pristimantis labiosus	NT	LC
Pristimantis luteolateralis	NT	NT
Pristimantis muricatus	V	V
Pristimantis scolodiscus	DD	EN
Rulyrana orejuela	DD	DD
Alopoglossus festae	NT	NE
Anolis aequatorialis	NT	NE
Anolis gemmosus	LC	LC
Basiliscus galeritus	NE	NE
Bothriechis schlegelii	NT	NE
Cercosaura vertebralis	DD	NE
Diaphorolepis wagneri	NT	NE
Lepidoblepharis conolepis	EN	NE

animals. This initial observation yielded two significant findings: the first evidence of an *A. olallai* population in 43 years and the second known locality for the species extending its known range 40 km N from its type locality.

During the course of the survey in May 2013 a total of 18 *A. olallai* were observed across four stream systems. Average nightly environmental conditions during the three nights of surveys in May were: air temperature 18.3 °C and relative humidity 92.8%. We recorded the presence of adults, juveniles, and froglets, indicating ongoing population recruitment (Fig. 3). Eleven of the nineteen individuals encountered were adults, and although their sex could not be determined, eggs were visible in the abdomen of two gravid females. The sex of one preserved adult male (QCAZ-A 55561) was confirmed by internal gonad examination. The confirmed adult females had SVL of 57 mm and 60 mm, considerably larger than the SVL reported by Hoogmoed (1985) for the holotype (♀, 39.6 mm). The single confirmed male had a SVL of 36.5 mm. Mean SVL for adults with unknown sex was 47.1 mm (n = 8).

All individuals encountered were perched on branches or leaves overhanging or bordering the streams. Mean perch height was 1.4 m (n = 18), with adults generally perching higher than younger individuals. Maximum observed perch height was four meters. Although no official surveys were conducted during the day, no individuals were observed along streams during random daytime walks. Although further behavioral work needs to be conducted, this observation suggests that *A. olallai* may be actively foraging during the day in the forests surrounding streams. At night, they remain immobile perched on leaves overhanging the streams. Lack of movement may protect them from predators.

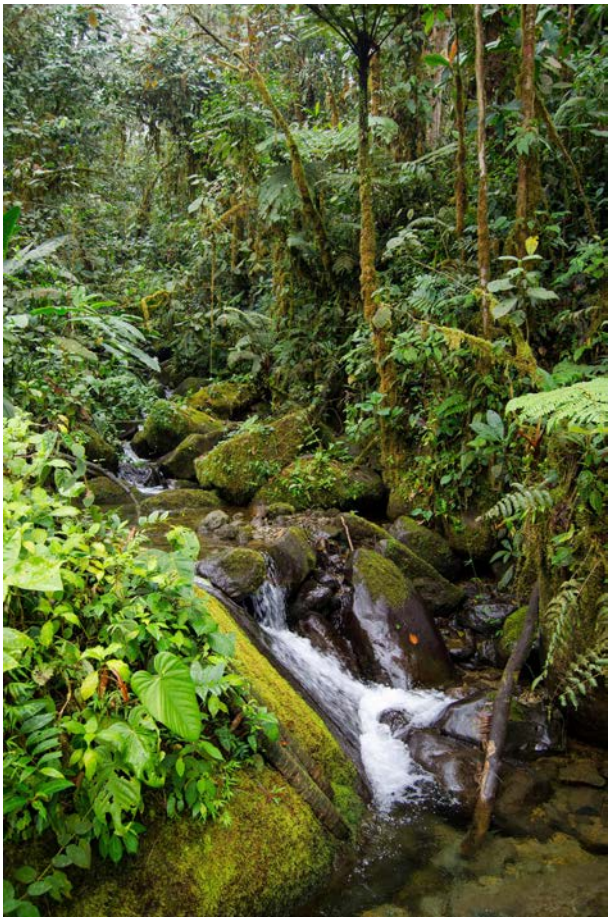

Fig. 2. *Andinophryne olallai* habitat from Río Manduriacu, Imbabura Province, Ecuador. All individuals encountered were found perched on branches or leaves along streams similar to the stream pictured here.

Ontogeny and Morphology

All information on *A. olallai* reported by Hoogmoed (1985) was based on two adult specimens. Our observations of froglets and juveniles mark the first reported information on the species' pre-adult morphology and ontogeny. Ontogenetic change in color pattern is considerable (Fig. 3), and is one of the few reported cases of such an extreme change in bufonids in Ecuador (see Hoffman and Blouin 2000). We observed a total of two froglets (mean SVL 13.1 mm) and five juveniles (mean SVL 26.6 mm). Froglets have a copper, gold, and white dorsum with a mottling pattern reminiscent of some species of *Atelopus* (Fig. 3: A, B). This contrasts with the patternless brown dorsum of the adults. The venter of froglets have a series of white undulating lines that extend the length of the body (Fig. 4). The iris in froglets and juveniles is more vibrantly red than in adults, which have a yellow copper-colored iris that is darker medially near the horizontally oval pupil. Froglets also differ from adults in lacking tubercles and parotoid glands. Juveniles retained some of the mottling pattern seen in froglets (primarily posteriorly on the hind legs) and lacked the conspicuous tubercles on the flank (Fig. 3: C, D). However, they begin to show adult traits like pronounced parotoid glands, tan-brown coloration, and strongly webbed fingers.

Morphological characteristics of the adults match those of the holotype of *A. olallai* (comparisons based on photographs of the holotype, available at Link/URL: Amphibiaweb Ecuador, and Hoogmoed 1985). The holotype and the observed specimens of the population from Manduriacu differ from the other species of the genus in having more developed parotoid glands, larger body size, strongly webbed fingers, and conspicuous yellowish glands scattered on the flanks and arranged in rows or in irregular patterns (Fig. 3: E, F) (Hoogmoed 1985). The dorsal texture varies from smooth to mildly tuberculate. One individual had abundant tubercles on the anterior half of the dorsum and large scattered tubercles on the posterior half. The description of coloration given by Hoogmoed (1985) was of an animal in preservative; however, the color description falls within the variation observed in life at Manduriacu. The only notable differ-

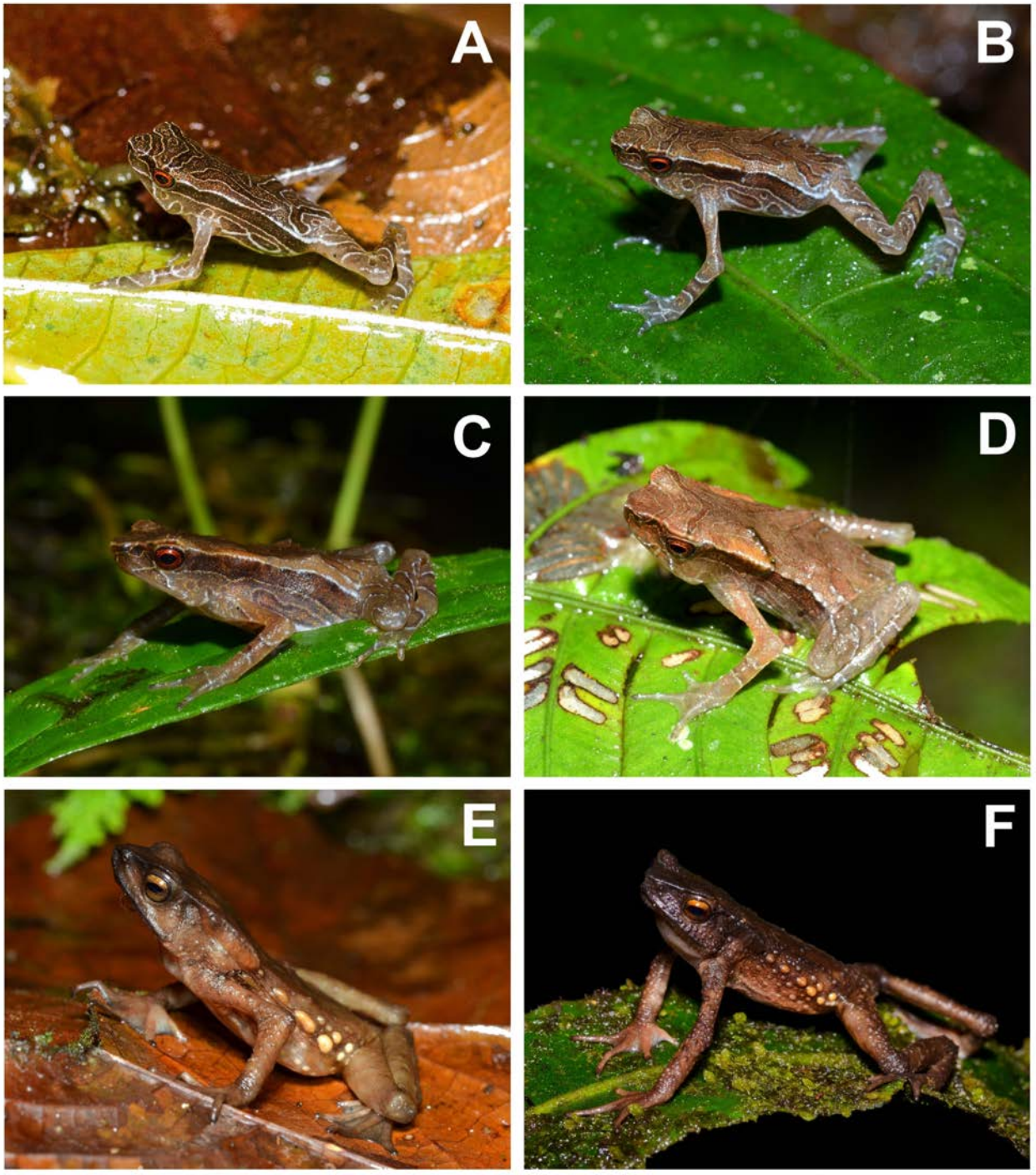

Fig. 3. Ontogenetic transformation of color and pattern in *Andinophryne olallai* from Río Manduriacu, Imbabura Province, Ecuador. (A) Froglet (11 mm SVL; *in situ*), (B) Froglet (15.1 mm SVL; *in situ*), (C) Juvenile (26.3 mm SVL; *in situ*), (D) Juvenile (28.1 mm SVL; *in situ*), (E) Adult (44.6 mm SVL; *ex situ*), (F) Adult (53.3 mm SVL; *in situ*). Note the progressive ontogenetic change in dorsal patterning from heavily mottled to no pattern; lack of parotoid glands and tubercles along the flank to presence of conspicuous parotoid glands and tubercles along the flank; a darkening of color from copper, tan, and white to dark brown; and iris color change from vibrant crimson to copper-orange.

Fig. 4. Ventral pattern of froglets of *Andinophryne olallai*. Manduriacu, Imbabura Province, Ecuador.

ence is that dorsal and flank coloration is not uniform in all individuals; the head and dorsum were darker brown than the light brown-tan flanks in most live animals observed at Manduriacu.

Sympatric Species

During our herpetofaunal surveys of Manduriacu we recorded observations of all amphibian and reptile species occurring at the site (Table 1). Most of these species are mid-elevation (1,000–2,500 m) inhabitants of premontane and cloud forests of the eastern Andes. A number of the species (i.e., *Lepidoblepharis conolepis*, *Pristimantis scolodiscus*) are either nationally or internationally listed as Endangered, and two of the species are categorized as Data Deficient or have not yet been assessed (i.e., *Diaphorolepis wagneri*, *Epipedobates darwinwallacei*) and very little is known about their biology or conservation status due to few available records or localities.

Conservation and Threats

Andinophryne olallai is currently classified as Data Deficient by the IUCN Red List (Coloma et al. 2010). However, more recent assessments considers *A. olallai* as Endangered based on its restricted range, the apparent extirpation of the species from the type locality and

Fig. 5. A recently deforested plot of land that is less than one km from the population of *Andinophryne olallai* in Manduriacu, Imbabura Province, Ecuador.

extensive habitat degradation (Coloma et al. 2011-2012; Ron and Frenkel 2013). The rarity of known distribution and a very small population size likely warrants an IUCN Red List status of Endangered.

Although we found evidence of a seemingly healthy population of *A. olallai* at Manduriacu, with the presence of all size classes across numerous stream systems, the extent of known occupancy remains extremely small (< 1 km^2). At present, pristine habitat still exists at Manduriacu, however, the surrounding forest is rapidly disappearing due to a variety of anthropogenic factors (i.e., intensive logging, mining, and hydroelectric development). These activities are expanding quickly and resulting in extensive habitat fragmentation and loss (Fig. 5). The apparent extirpation of *A. olallai* from the type locality, a site where forest has been lost and fragmented, suggests that the species is sensitive to anthropogenic habitat change. Urgent conservation measures and population monitoring are needed in order to ensure the survival of *A. olallai* in nature. It is our hope that the rediscovery of *A. olallai* will result in immediate support for greater protection of the forests in and around Manduriacu, and provide assistance in creating biological corridors between the neighboring reserves of Los Cedros and Cotacachi-Cayapas.

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Sebastián Kohn is the administrator for the Antisanilla-Sunfohuaico Reserve run by the Jocotoco Foundation in Ecuador. He received his B.A. in biology and environmental studies at Whitman College in Washington State, USA. He currently directs the Río Manduriaco Cooperative in Imbabura, Ecuador, as well as the Ilitio Wildlife Rescue Center and Hacienda Ilitio in Cotopaxi, Ecuador. Sebastián is a founding member of the Andean Condor Conservation Group of Ecuador (Grupo Nacional de Trabajo del Cóndor Andino) and has been working with, and researching, both wild and captive condors for ten years.

Fernando Ayala-Varela is the director of the herpetology collection at the Pontificia Universidad Católica del Ecuador in Quito. He received his diploma at the Pontificia Universidad Católica del Ecuador, Quito in 2004. He has been interested in herpetology since childhood and has dedicated a lot of time studying the lizards of Ecuador, specifically the taxonomy and ecology of *Anolis* species. His current research interests include reproductive biology and ecology of lizards and snakes in Ecuador.

Paul S. Hamilton is the founder and executive director of The Biodiversity Group in Tucson, Arizona, USA. He holds a master's degree in biology from the University of California, Riverside, and a Ph.D. in biology from Arizona State University, and has conducted field studies in evolutionary, behavioral and conservation ecology both in the tropics and the desert southwest. In addition to his research interests in ecology and conservation of overlooked species such as amphibians, reptiles, and invertebrates, he is also a well published scientific and artistic photographer.

Santiago R. Ron is the curator of amphibians and professor at the Pontificia Universidad Católica del Ecuador in Quito. His research focuses on the evolution and diversity of neotropical amphibians with emphasis on Ecuador. Areas covered include evolution of animal communication, sexual selection, systematics and taxonomy. In the area of conservation biology Santiago is interested in the study of amphibian extinctions in the Andes. Santiago also oversees the *ex situ* amphibian conservation project Balsa de los Sapos at the Pontificia Universidad Católica del Ecuador in Quito.