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Research Article

Current state of conservation knowledge on threatened amphibian species in Peru

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Abstract
This study documents the current state of conservation knowledge on threatened amphibian species in Peru. Following the International Union for the Conservation of Nature (IUCN) classification system, we considered species in the following categories: Critically Endangered, Endangered, Vulnerable, and Near Threatened. Even though only the first three categories are regarded as threatened by IUCN, we included the fourth category to make comparisons with the list of threatened species issued by the Peruvian government. We used the Global Amphibian Assessment's database and the list issued in Peru for this comparison. We conducted separate field surveys in 17 regions of Peru to evaluate the presence/absence of threatened amphibian species and species that are potentially threatened. We also used the Declining Amphibian Database–DAPTF, to compare our results with previous assessments on population declines, and the World Wildlife Fund's Wildfinder database, to determine in which Neotropical ecoregion each species occurs. We compiled data on 83 species, 44 of which are recognized as threatened by the IUCN and/or the Peruvian government. The remaining 39 species should be re-assessed as they face various threats. A re-evaluation of current estimates is needed as only 8% of all species recorded in Peru are recognized as threatened by the government, whereas the global estimate of threatened species is about 32%. In addition to using IUCN criteria, this re-assessment should follow national guidelines standardized in Peru and be in accordance with the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Because the habitat of almost 40% of threatened species reported herein still remains unprotected, and data on chytridiomycosis and other threats are lacking for most taxa, it is crucial to develop strategies for habitat conservation and research on disease dynamics in natural populations.

Keywords: amphibian conservation, population declines, Peru, protected areas

Resumen
Este estudio presenta información actualizada sobre conservación de especies amenazadas de anfibios en Perú. Consideramos las siguientes categorías según la Unión Internacional para la Conservación de la Naturaleza (UICN): En Peligro Crítico, En Peligro, Vulnerable y Casi Amenazado. Sólo las tres primeras categorías son consideradas como amenazadas según UICN, sin embargo incluimos la cuarta categoría para hacer comparaciones con la lista de especies amenazadas emitida por el gobierno peruano. Usamos la base de datos de la Evaluación Global de Anfibios y la lista emitida en Perú para hacer esta comparación. Asimismo, hicimos evaluaciones de campo en 17 regiones de Perú para evaluar la presencia/ausencia de especies amenazadas y especies que podrían estar amenazadas. También comparamos nuestros resultados de campo con otras bases de datos. Compilamos datos sobre 83 especies, 44 de ellas reconocidas como amenazadas por la UICN y/o el gobierno peruano. Las otras 39 especies deberían ser re-evaluadas debido a que enfrentan varias amenazas. Esta re-evaluación es necesaria debido a que el gobierno reconoce sólo 8% de las especies de anfibios en Perú como amenazadas. En cambio, el estimado global reconoce como amenazadas al 32% de especies de anfibios del planeta. Además de usar criterios de UICN, esta re-evaluación debería incluir estándares usados en Perú y otros países. Debido a que el hábitat de casi 40% de las especies amenazadas reportadas aquí no tiene ninguna protección, y debido a que no existen datos sobre quitridiomicosis, es necesario desarrollar estrategias de conservación del hábitat y estudios de dinámica de infección en poblaciones naturales.

Palabras clave: anfibios, áreas naturales protegidas, conservación, disminución poblacional, Perú

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Introduction

Peru is a mega-diverse country with approximately 500 amphibian species known to date [1]. According to the Instituto Nacional de Recursos Naturales (INRENA), the governmental institution in charge of regulating the conservation and use of natural protected areas, biodiversity, and renewable resources in Peru, only 38 species (~8%) have been classified as threatened [2]. These species have been included in one of the following categories: Critically Endangered, Endangered, Vulnerable, and Near Threatened. These categories were developed by the International Union for Conservation of Nature (IUCN, also known as the World Conservation Union), the largest global environmental network [3]. The IUCN Red List of Threatened Species provides a system with which to classify species in categories representing their conservation status (Table 1). In addition to two categories for extinct taxa, one for species not evaluated, and one for data-deficient species, three categories qualify as threatened (Critically Endangered

or CR, Endangered or EN, Vulnerable or VU) and two qualify as "lower-risk" categories (Near Threatened or NT, Least Concern or LC; Table 1) [3]. According to the Global Amphibian Assessment [4] and following the four threat categories used by INRENA (Table 1), 93 amphibian species (~19%) in Peru have been classified as threatened (even though NT does not qualify as threatened by IUCN, we included it in the threatened categories to allow comparisons with INRENA's list of threatened species).

Field work conducted during the past decade has increased the amount of knowledge on threatened amphibian species in Peru. This increase in effort to document threatened species represents the first step in updating information presented previously by the Global Amphibian Assessment [4]. It is crucial to consistently update this information in view of current population declines worldwide [4,5].

The main goal of this study was to document the current state of conservation knowledge on threatened amphibian species in Peru. These species are included in the IUCN Red List [4] and/or INRENA's list of threatened species [2]. There is some overlap between these lists, but far less than expected. To address this goal, we included information obtained through surveys conducted between 1998 and 2008 which focused on assessing the presence/absence and relative abundance of threatened amphibians within their geographical ranges. If a threatened species was not surveyed within the past 10 years, we referred to the most recent account. This study follows guidelines proposed by the Amphibian Conservation Action Plan (ACAP), particularly those that emphasize that the Global Amphibian Assessment must be a continuous, ongoing process crucial for amphibian conservation worldwide [5]. We update the knowledge on the status of threatened amphibians in Peru based on numerous individual surveys that we conducted throughout Peru. Data on each species' relative abundance, the number of separate populations, the quality and extent of suitable habitat, and their health status (e.g., chytridiomycosis), will be published separately by the co-authors of the present study.

Table 1. IUCN categories and INRENA categories (acronyms in parentheses). Four IUCN categories were considered as threatened in this study, to facilitate comparisons with INRENA's list of threatened species.

IUCN categories	INRENA categories
Extinct (EX)	
Extinct in the Wild (EW)	
Critically Endangered (CR)	Critically Endangered (CR)
Endangered (EN)	Endangered (EN)
Vulnerable (VU)	Vulnerable (VU)
Near Threatened (NT)	Near Threatened (NT)
Least Concern (LC)	
Data Deficient (DD)	
Not Evaluated (NE)	

Methods

During the past decade (1998-2008), we conducted separate trips to one or more sites within each species' geographic range in Peru. These expeditions were carried out in the following 17 *Regiones* (a *Región* is equivalent to a federal state and was formerly known as *Departamento*): Amazonas, Ancash, Arequipa, Ayacucho, Cajamarca, Cusco, Huánuco, Ica, Junín, La Libertad, Lima, Loreto, Madre de Dios, Pasco, Puno, San Martín, and Ucayali (Fig. 1). We evaluated the presence of each threatened species through a variety of sampling techniques that primarily included visual encounter surveys [6]. Where possible, we visited the type locality and sampled the surrounding areas that resembled the type locality. To increase the chance of encountering

amphibian species, most sampling was conducted during both wet and dry seasons according to local rainfall patterns. For each individual study, the effort was measured in person-days and the total number of individuals found was recorded. Because data on relative abundance were recorded using different methods by different co-authors (e.g., number of individuals per transect in nocturnal visual encounter surveys; number of individuals per plot in leaf-litter plots), we estimated the approximate number of person-days invested in the surveys as a general effort measure (e.g., 2 people x 3 days of field work = 6 person-days). We consider this to be the most conservative approach for obtaining an effort measure that is comparable across surveys. The status of the species' habitat was generally described as being undisturbed or disturbed (e.g., old-growth forest vs. secondary forest; undisturbed puna grassland vs. disturbed puna grassland), and the type of human-induced threat was noted. We also recorded the known elevational range of the species and whether the species was found inside or outside of natural protected areas. We collected and deposited voucher specimens in one of the following institutions in Peru: Museo de Historia Natural Universidad Nacional Mayor de San Marcos (MUSM), Museo de Historia Natural Universidad de San Antonio Abad del Cusco (MHNC), Museo de Historia Natural Universidad Nacional de San Agustín de Arequipa, and Centro de Ornitología y Biodiversidad (CORBIDI).

The IUCN Red List uses nine categories to describe the status of a species (Table 1). We used the Global Amphibian Assessment's (GAA) database [4] to determine the number of species classified in each of the IUCN Red List categories in Peru. To make search results comparable to INRENA's list of threatened species, which includes four categories of threatened species (CR, EN, VU, NT), we conducted a search by entering the following criteria: (a) Group: Amphibia (entire group selected); (b) IUCN Red List Status: CR, EN, VU, NT; (c) Location: Country PE. We conducted two more searches maintaining criteria (a) and (c), and varying criterion (b). The second search excluded the four categories above (VU, NT, CR, or EN) and included only LC and DD, as these two categories are also included in the GAA database. Finally, the third search excluded all previous categories above and included only EX and EW.

We compared the number of species included in each threat category, according to the GAA and INRENA, to evaluate the congruence between the two classifications. A similar comparison was made by Angulo [7] for species of two Andean genera in Peru.

We used information from two other databases to complement the species-level assessment outlined above and our own database. First, we used the Declining Amphibian Database-DAPTF [8], which provides an assessment of declines at the population level. We searched for Peruvian amphibians in this database to determine if any species faces extinction risk or other threats at the population level. Then we used the World Wildlife Fund's (WWF) Wildfinder database [9], to determine which Neotropical ecoregion is occupied by each species. To determine whether a species was endemic to Peru, we used information and maps available in the GAA database [4]. If a species was not included in the GAA database, we referred to the Amphibian Species of the World database [1] or to the original description in order to obtain information on its geographic range. Furthermore, because life-history traits such as developmental mode can influence the type of response to environmental changes and should be taken into account in the selection of priority areas for conservation [10], we included the general type of development (aquatic larvae vs. terrestrial development) of each species.

Fig. 1. Political map of Peru showing the country's Regions. One or more surveys were carried out in each of the 17 Regions denoted with abbreviations (in parentheses): Amazonas (Ama), Ancash (Anc), Arequipa (Are), Ayacucho (Aya), Cajamarca (Caj), Cusco (Cus), Huánuco (Hua), Ica (Ica), Junín (Jun), La Libertad (Lal), Lima (Lim), Loreto (Lor), Madre de Dios (Mad), Pasco (Pas), Puno (Pun), San Martín (San), Ucayali (Uca). The inset shows the location of Peru in South America. Modified from image available in Wikimedia Commons (http://commons.wikimedia.org/wiki/Image:Peru-Blank.png, accessed on 30 July 2008), obtained with permission under the terms of the GNU Free Documentation License.

We also considered potentially threatened species, based on decline patterns observed in neighboring Andean countries [11,12] and/or on documented local or regional declines that have occurred over short periods of time during the past five years. Our perception of potential threat was mostly based on phylogenetic relationships of specific taxa (i.e., species that belong to genera that exhibited population declines in other regions—*Atelopus*, *Telmatobius*, centrolenid species, etc.) and stream-dwelling species that have undergone significant declines in the Neotropical region [12,13,14].

Results

We compiled data on 83 species of amphibians, most of which were surveyed within the last five years (Appendices 1 and 2). Eighty species are anurans and three species are caecilians. The latter are not known to be threatened in Peru, but were included in this study because of their rarity. In contrast, salamanders (only two recognized species in Peru) were not included as they are common in several lowland rainforest sites. Forty-four species are recognized as threatened by the GAA, INRENA, or both, and have been included in one of the following four categories: CR, EN, VU, NT (Appendix 1). Thirty-nine species are likely to be threatened, but they currently are not included in any threat category or are categorized as LC or DD (Appendix 2).

There was no congruence between the GAA and INRENA threat categories and the number of amphibian species included in each category (Fig. 2). According to the GAA, most species were categorized as CR, EN, VU, and only 13% were categorized as NT. In contrast, according to INRENA, 50% were categorized as NT while the other 50% were distributed among the remaining categories (Fig. 2). Only two species in Peru are considered to be Critically Endangered, according to INRENA.

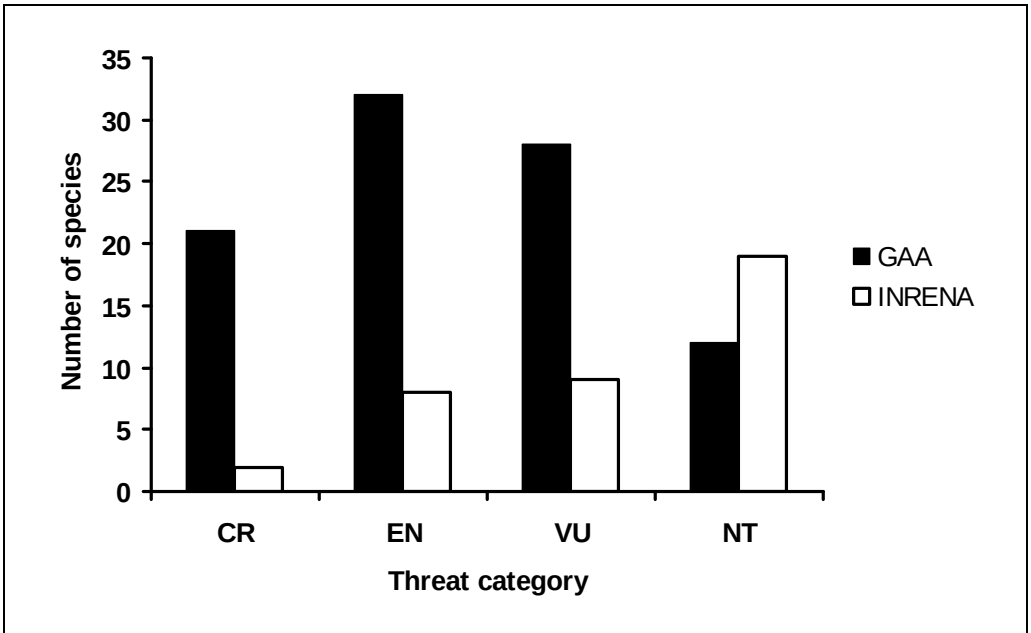

Fig. 2. Number of threatened amphibian species in Peru, according to the GAA (IUCN et al., [4]) and INRENA. Threat categories: Critically Endangered (CR), Endangered (EN), Vulnerable (VU), and Near Threatened (NT).

Almost 40% of threatened amphibian species reported herein (17 species) occur outside natural protected areas in Peru (Appendix 1). The remaining 27 species occur inside natural protected areas. (Even though locality data were missing for *Telmatobius culeus*, as data reported pertain to market surveys in the city of Cusco [15], the species is known to occur inside the Titicaca National Reserve.) We also found that more than 50% of potentially threatened amphibians (20 species) occur outside natural protected areas (Appendix 2).

We found that 32 (out of 44) threatened species evaluated in this study are endemic to Peru [4]. In turn, the following 12 threatened species are not endemic to Peru (neighboring countries in which they occur are in parentheses): *Ameerega parvula* (Ecuador), *A. petersi* (Brazil), *Atelopus pachydermus* (Ecuador), *A. spumarius* (Brazil, Colombia, Ecuador, French Guyana, Guyana, Suriname), *A. tricolor* (Bolivia), *Cochranella resplendens* (Ecuador, Colombia), *Pristimantis schultei* (Ecuador), *Ranitomeya reticulata* (Ecuador), *Rhinella* aff. *festae* (Ecuador), *R. spinulosa* (Argentina, Bolivia, Chile), *Telmatobius culeus* (Bolivia), and *T. marmoratus* (Bolivia, Chile). All of these species, with the exception of *C. resplendens* and *R. spinulosa* occur in protected areas in Peru (Appendix 1). *C. resplendens* does not occur in any protected area in neighboring countries either, whereas *R. spinulosa* occurs in several protected areas in Argentina and Chile [4].

We found that 30 (out of 39) species likely to be threatened are endemic to Peru [4]. In turn, the following nine species likely to be threatened are not endemic to Peru (neighboring countries in which they occur are in parentheses): *Ameerega macero* (Brazil), *Epicrionops bicolor* (Colombia, Ecuador), *Gastrotheca monticola* (Ecuador), *Oscaecilia bassleri* (Ecuador), *Pleurodema marmoratum* (Argentina, Bolivia, Chile), *Ranitomeya biolat* (Bolivia), *R. vanzolinii* (Brazil), *Siphonops annulatus* (11 South American countries), and *Telmatobius timens* (Bolivia). All of these species, with the exception of *O. bassleri* and *R. vanzolinii*, occur in protected areas in Peru (Appendix 2). *O. bassleri* occurs in at least one protected area in Ecuador, whereas *R. vanzolinii* occurs in several protected areas in Brazil [4].

Our survey results show that no individuals of six threatened species have been recorded during the past five years in their historical ranges. These species (*Atelopus peruensis*, *A. reticulatus*, *A. tricolor*, *Cochranella euhystrix*, *C. saxiscandens*, *Nannophryne corynetes*) occur at elevational ranges between 850 and 4300 m covering various types of montane forest and puna grassland habitats (Fig. 3); surveys included more than one visit to the study sites and effort varied between 4 and 112 person-days (Appendix 1).

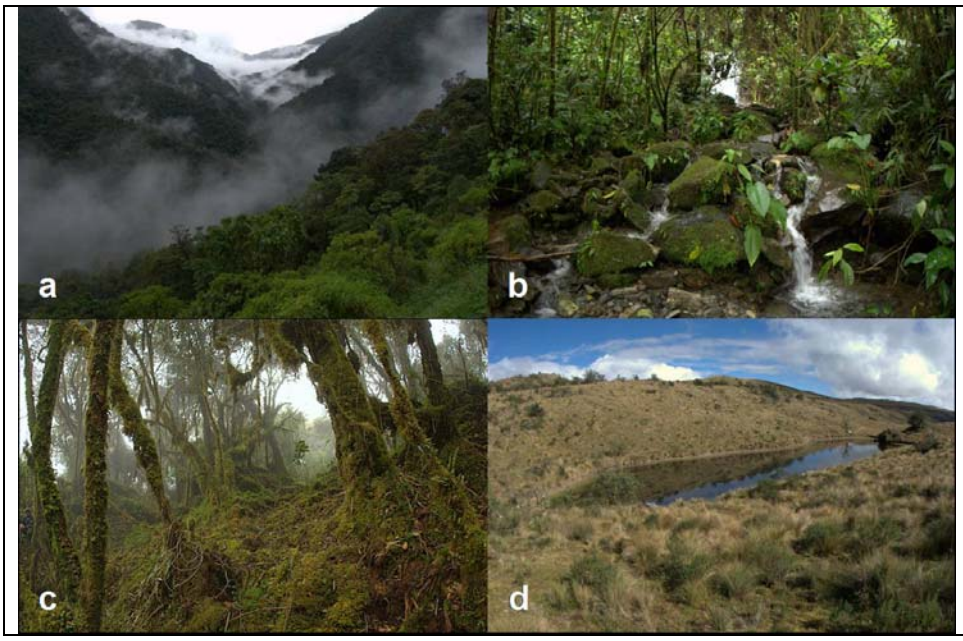

Fig. 3. Most threatened amphibians in Peru inhabit various types of montane forest and puna grassland habitats: (a) Cloud forest in Manu National Park, (b) montane forest stream, (c) elfin forest and mosses, (d) puna grassland and high-Andean lake (all photographs by A. Catenazzi).

From our search in the GAA database [4], we found that 93 species were included in one of the following categories: CR, EN, VU, or NT. Our second search in the GAA database resulted in 318 species categorized as either LC or DD. Our third search resulted in 0 species categorized as EX or EW, indicating that no species in Peru have been reported to be extinct.

From our search in the Declining Amphibian Database-DAPTF [8], we found that there were no records on amphibian species in Peru exhibiting population declines up to the time of the assessment (data from Peru were collected between 1985 and 1993; see references in [8]). Only three Peruvian sites were included in this assessment, all located in the lowland rainforest of Madre de Dios Region (Cocha Cashu, Pakitza, and Cusco Amazónico). In addition to this assessment, the following six amphibian species were considered to be Critically Endangered (although no population data were included in the database because these species do not occur in the three evaluated sites) [8]: *Atelopus peruensis*, *Atelopus* sp., *Batrachophrynus macrostomus*, *Excidobates* (formerly *Dendrobates*) *mysteriosus*, *Hyloxalus* (formerly *Colostethus*) *littoralis*, and *Telmatobius arequipensis*. We present updated data on three of these species (*A. peruensis*, *E. mysteriosus*, and *T. arequipensis*; Appendix 1).

From our search in the WWF's Wildfinder database [9], we found that threatened Peruvian amphibians occupy the following 11 Neotropical ecoregions in Peru (ecoregion codes in parentheses): Central Andean puna (NT1002), Central Andean wet puna (NT1003), Cordillera Central paramo (NT1004), Eastern Cordillera Real montane forests (NT0121), Iquitos varzea (NT0128), Napo moist forests (NT0142), Peruvian yungas (NT0153), Southwest Amazon moist forest (NT0166), Ucayali moist forests (NT0174), Maranon dry forests (NT0223), and Sechura desert (NT1315). Two ecoregions, Peruvian yungas and Central Andean wet puna, contained

most threatened species (27 and 11, respectively). Only three endemic threatened species evaluated occur in more than one ecoregion (*Psychrophrynella usurpator* occurs in the Central Andean wet puna and the Peruvian yungas; *Telmatobius arequipensis* occurs in the Central Andean puna and the Sechura desert; *Telmatobius brevipes* occurs in the Cordillera Central paramo and the Peruvian yungas [9]). A fourth endemic, *Phrynopus horstpauli*, appears to occur in two ecoregions according to its geographic distribution [4] (Central Andean wet puna and Peruvian yungas; ecoregion information not available in [9]). In contrast, most non-endemic species occupy two or more ecoregions in other countries (an extreme case is *Atelopus spumarius*, which may occur in 17 ecoregions) [9].

Our dataset indicates that threatened amphibians in Peru exhibit two general types of developmental mode, as 33 species have aquatic larvae and only 11 have terrestrial development. In genera with aquatic larvae (*Atelopus*, *Nannophryne*, *Rhinella*, *Centrolene*, *Cochranella*, *Telmatobius*, *Ameerega*, *Excidobates*, *Hyloxalus*, *Ranitomeya*; Appendix 1), the tadpoles typically develop in a body of water. The particular type of water body used for tadpole development varies according to the genus or species and may include streams, stream-side pools, Andean lakes, ponds of various sizes, and pools contained in plant structures (phytotelmata). In bufonids and ceratophryids, eggs are typically laid in the water, whereas in centrolenids and dendrobatids, eggs are typically laid on leaves or other substrates outside of the water (with tadpoles later developing in water). Species with terrestrial development typically lay eggs on land or vegetation, and exhibit direct development (species in the genera *Bryophryne*, *Phrynopus*, *Pristimantis*, *Psychrophrynella*) or eggs and larvae are carried in a dorsal pouch (e.g., some species of marsupial frogs in the genus *Gastrotheca*).

Discussion

The list of threatened fauna recognized by the Peruvian government includes 38 amphibian species [2], or about 8% out of approximately 500 species currently recorded in Peru [1]. In contrast, the global estimate of threatened species is about 32% (1,856 species from 5,743 known species at the time of the assessment [16]). This global estimate, which does not include the NT category, is four times larger than the proportion of threatened amphibians recognized by the Peruvian government. This estimate is also higher than the proportion of threatened Peruvian amphibians according to the GAA, which includes about 19% of the amphibians reported in Peru. Estimates of threatened species in neighboring countries are also larger than that of Peru. For example, there are 163 threatened species in Ecuador, which amount to about 36% of the amphibian species reported in that country [3]; there are 209 threatened species in Colombia, which amount to 30% of the amphibian species in that country [4] (again, both estimates do not include the NT category). These results suggest three possible scenarios: (a) current figures from other tropical Andean countries are overestimating the number of threatened amphibian species; (b) current figures in other tropical Andean countries may actually reflect a higher number of threatened species resulting from widespread habitat loss and other negative impacts in those countries than in Peru; (c) the figures from Peru are underestimating the number of threatened species in the country. In any event, a re-evaluation is needed to address the state of amphibian populations across Peru and perhaps in neighboring countries. Most importantly, we must acknowledge that the total number of amphibian species known from Peru is relatively low compared to that of some tropical Andean countries (i.e., Colombia and Ecuador). Given that the number of described species in Peru will continue to increase (approximately between 10 and 20 new amphibian species are being described every year), and that greater attention is being paid to conservation status assessments, it is plausible that more species will be categorized as threatened in the near future.

The lack of congruence between the GAA and INRENA threat categories and the number of amphibian species included in each category (Fig. 2) also indicates that future assessment efforts

should consider standardized criteria when updating the list of threatened species in Peru. One possible explanation for this difference is that the INRENA assessment in Peru did not follow these criteria for ranking each evaluated species. For example, the categorization of amphibians in Argentina included the assignment of numerical values for each species' attributes such as its continental distribution, national distribution, habitat use, observed abundance, degree of protection, and taxonomic singularity [8]. Based on the sum of numerical values, species were classified into different threat (or non-threat) categories. In Peru, the inclusion of only two species in the highest threat category (CR) on the INRENA list appears to be an extreme underestimation compared to more than 20 species listed as CR by the GAA (Figure 2; see also Fig. 4, depicting some of these species). We obtained data on only one of the species listed as CR by INRENA. This species, *Ameerega planipaleae*, was recorded outside a national park (Yanachaga-Chemillén National Park, in Pasco Region) and inhabits stream-side habitats surrounded by agricultural areas and human populations. Even though the species was recorded less than 0.5 km from the national park's boundary, it is necessary to conduct more field surveys to confirm its presence inside a protected area (G. Chávez, M. Medina-Müller, R. von May, unpublished data).

Fig. 4. Some threatened amphibian species in Peru. (a) *Atelopus* aff. *andinus* (photograph by C. Torres), (b) *Atelopus pulcher* (photograph by J. Carrillo), (c) *Atelopus peruensis* (photograph by J.H. Córdova), (d) *Telmatobius arequipensis* (photograph by A.J. Quiroz), (e) *Telmatobius brevipes* (photograph by A. Miranda), (f) *Telmatobius marmoratus* juvenile (photograph by A. Catenazzi), (g) *Gastrotheca excubitor* (photograph by A. Catenazzi), (h) *Bryophryne cophites* (photograph by A. Catenazzi), (i) *Ameerega parvula* (photograph by G. Chávez).

Our results indicate that more than two-thirds (~72%) of the evaluated threatened amphibian species are endemic to Peru and, overall, threatened amphibians occupy 11 Neotropical ecoregions in Peru. Most endemic amphibians in Peru occupy only one ecoregion, and only three endemic species occupy two ecoregions (see results). In contrast, most non-endemic amphibians occupy two or more ecoregions found in Peru and other countries. Seven ecoregions in Peru (Central Andean puna, Central Andean wet puna, Cordillera Central paramo, Eastern Cordillera Real montane forests, Napo moist forests, Peruvian yungas, and Ucayali moist forests) belong to the "priority ecoregion set" proposed by Loyola et al. [10] for representing all Neotropical anurans considered to be threatened. However, if we consider some of the species likely to be threatened (Appendix 2), the remaining ecoregions in Peru would be included in this priority set. For example, *Atelopus patazensis* occurs in the Maranon dry forests [17] and *Rhinella limensis* occurs in the Sechura desert [9]. If both species are categorized as threatened, then both ecoregions should be included in the proposed priority ecoregion set [10]. The fact that most threatened amphibians evaluated in this study occur in priority ecoregions, and that about 40% of them occur outside of protected areas in Peru, indicates that habitat conservation is a priority.

Our search in the Declining Amphibian Database-DAPTF indicates that no amphibian species evaluated in Peru exhibited population declines up to the time of the assessment [8]. Because the DAPTF database included only sites located in the lowlands (<400 m in elevation) of southern Peru, it overlooked regions where observed trends indicate that declines are occurring at higher elevations [18,19]. Even recent reports that used the DAPTF database for assessing amphibian population declines on continental and global scales acknowledged that fewer than five records of declines exist from Peru [20]. This figure most likely underestimates the extent of population declines in Peru, as data were collected between 1985 and 1993 (see references in [8]). In any event, our results indicate that more species have experienced a reduction in relative abundance in recent years (Appendices 1 and 2).

The DAPTF database considered that six species of Peruvian amphibians should be treated as Critically Endangered despite the fact that no population data were presented (the DAPTF referred to an unpublished report from 1992 [8]), as these species do not occur in the evaluated sites. In any event, we present updated data for three of these six species (*Atelopus peruensis*, *Excidobates mysteriosus*, and *Telmatobius arequipensis*; Appendix 1). We did not assess the status of the other three species in our surveys, but recognize the need to obtain updated information. Two of these species, *Hyloxalus littoralis* and *Batrachophrynus macrostomus*, are endemic to Peru, have small geographic ranges, and face habitat degradation. *H. littoralis* is listed as LC by the GAA and is present in one protected area, Pantanos de Villa Reserved Zone, although it was apparently introduced to that area in Lima from its original range in Ancash and Huánuco [4]. *B. macrostomus* is listed as CR by INRENA and as EN by the GAA, and is also present in one protected area (Junín National Reserve) [4]. The populations of these species could initially be evaluated inside the protected areas in which they occur. The sixth species considered to be Critically Endangered by the DAPTF database is *Atelopus* sp.; however, the taxonomic status and geographic location of this species needs clarification prior to conducting assessments.

According to our dataset, it is likely that populations of at least six threatened species may be facing local extinction as no individuals have been recorded during the past five years. These species (*Atelopus peruensis*, *A. reticulatus*, *A. tricolor*, *Nannophryne corynetes*, *Cochranella euhystrix*, *C. saxiscandens*) were classified in various threat categories by the GAA or INRENA (Appendix 1). Four of these species have not been reported despite intensive field work (i.e., 20 or more person-days), whereas the absence of the other two may have resulted from the lack of intensive sampling. One of the former species, *A. peruensis*, was recorded in Cajamarca before 2002, but not in the most recent surveys (Appendix 1; J.H. Córdova, personal observation). In former surveys conducted 10 years ago, *A. peruensis* was relatively common in Cajamarca and Ancash (Appendix 1; A. Miranda and A.W. Salas, personal observation). For *A. reticulatus*, the last confirmed sighting occurred in 1992 [4]. *A. tricolor* is another species that experienced a dramatic decline, as it has not been found over the past 13 years despite extensive field work (Appendix 1; A. Catenazzi, unpublished data).

A seventh species, *Telmatobius marmoratus*, has experienced a drastic decline in at least one survey site and has been shown to be infected by *Batrachochytrium dendrobatidis* (*Bd*) [19]. This species is also harvested for human consumption, which typically affects several *Telmatobius* species (Fig. 5a) [15]. Because sampling at other sites has been minimal, it is hard to predict whether this species is declining at other geographic locations. However, based on local reports of *Telmatobius* disappearing from other sites in Peru and Ecuador ([21] and A. Catenazzi, A. Miranda, A.W. Salas, unpublished data), and the presence of *Bd* in many Andean localities [18,19,21,22,23], the decline of *Telmatobius* is suspected to be widespread and to encompass other species in this genus [24]. *Telmatobius timens* seems to have disappeared from the upper Manu National Park, in Cusco Region (Appendix 2), where it was frequently observed until 1999.

Another undescribed *Telmatobius* species from Cusco Region (Fig. 5b), which had a broad elevational distribution in the 1970s (W.E. Duellman, personal communication to A. Catenazzi), was last seen in 2007 (one calling male, no tadpoles) at a spring where frogs had been heard calling and tadpoles had been consistently found during each survey over the past 12 years. Preliminary data indicate the arrival of *Bd* to this region between 2000 and 2007 (A. Catenazzi, unpublished data). *Pleurodema marmoratum* is another high-Andean frog found to be infected by *Bd* although available data do not indicate drastic declines [19]. However, local farmers near Marcapata, Cusco, found dead individuals of *P. marmoratum* during field work in March 2008 and indicated that populations of this species appear to have declined over the past five years (personal communication to A. Catenazzi).

Relative abundance patterns recorded over the past ten years suggest that populations of almost 20 species have declined within the last two decades (Appendices 1 and 2; see below). Overall, species in the genera *Atelopus*, *Centrolene*, *Cochranella*, *Nannophryne*, *Phrynopus*, *Rhinella*, and *Telmatobius* appear to have declined in various geographic locations in Peru. These patterns confirm similar patterns observed in other Latin American countries [11,12,14,16,21,22]. However, long-term surveys are needed to differentiate natural population fluctuations from real declines [25].

Neotropical poison frogs (genera *Ameerega*, *Excidobates*, *Hyloxalus*, *Ranitomeya*) are threatened by smuggling for the pet trade. Many poison frogs are not considered as threatened in the GAA or INRENA lists; however, their inclusion in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) list [26] suggests that their current threat status may need to be re-evaluated. CITES's Appendix II includes many species of poison frogs that are not currently threatened with extinction, but which may become threatened in the future because of the uncontrolled pet trade [26]. For instance, *Ameerega silverstonei* is a poison frog that is consistently smuggled through Pucallpa (Ucayali Region) and current populations are smaller (8 individuals/15 person-days; E. Twomey, personal observation) compared to historical records (26 individuals/6 person-days in 1979 [27]). *Excidobates captivus* is another poison frog that was recently smuggled to Germany (March 2008; J.L. Brown, personal observation).

Harlequin frogs (*Atelopus*) are also affected by smuggling for the pet trade, but infection by *Bd* is considered the main threat for most species in this genus. There is ample evidence indicating an especially negative effect of *Bd* on *Atelopus* populations [12,14,22,23]. *Atelopus pulcher* is a harlequin frog that has experienced a dramatic decline: in the early 1980s the species was abundant near montane rivers in eastern San Martin, as 20-40 individuals could be found in a single day at a single locality (R. Schulte and W.E. Duellman, personal communication to J.L. Brown). This species is now infected by *Bd* (J.L. Brown, unpublished data) and post-infection populations appear to be threatened by habitat destruction. *Atelopus patazensis* [17] is a new species that has also been found to be infected by *Bd* and is most likely extinct. An examination of skin sections of *A. patazensis* revealed that four specimens collected in 1993 were not infected by *Bd*, whereas two of three specimens collected in 1999 contained zoosporangia of the chytrid fungus [17]. This case represents the first confirmed historical record of *Bd* infection in Peru.

Because certain frogs can be an important source of protein and are used in traditional medicine, human consumption is another cause of population decline in these species [15]. *Telmatobius culeus* and *Telmatobius* aff. *marmoratus* are two Andean species that can be typically seen on display at the Central Market in Cusco (Fig. 5a). It is difficult to estimate how many frogs are sold throughout an entire day because vendors only display a limited number of frogs at one time [15].

The demand of vertebrate specimens for educational purposes, a different type of human consumption, threatens at least one amphibian species. *Rhinella limensis* (Fig. 5c) is considered an 'ideal' study organism for practical classes in schools, colleges, and universities, as well as for pregnancy tests (J.H. Córdova, personal observation). This species may have experienced local extinctions along the Peruvian coast and neighboring Andean foothills. Previous surveys conducted in the year 2000 found 23 individuals south of Lima (J.H. Córdova, personal observation), whereas only three individuals were found in more than 140 person-days of field work in more recent years (Appendix 2).

In a few cases, the population status of some species is completely unknown as no individuals have been seen for decades. For instance, *Phrynopus ayacucho* is an Andean frog whose description was based on preserved material collected approximately 50 years ago and has not been seen in the wild [28]. Likewise, the description of *Phrynopus kotosh* was based on preserved specimens collected about 40 years ago and the species has not been collected since 1969 [28].

Fig. 5. Human consumption may be the cause of population decline for several amphibians in Peru. (a) Skinned and gutted bodies of *Telmatobius* specimens (unidentified species, but possibly *T. culeus* or *T. marmoratus*) sold for human consumption at local markets in Cusco (photograph by A. Angulo). (b) An undescribed *Telmatobius* species, at a spring where males had been heard calling and tadpoles had been consistently found during each survey over the past 12 years; only one individual (one male, no tadpoles) was seen in 2007 (photograph by A. Catenazzi). (c) An undetermined number of *Rhinella limensis* are collected every year for educational purposes as the species is used as study organism for practical classes in schools, colleges, and universities, as well as for pregnancy tests (photograph by J.H. Córdova).

Implications for Conservation

Habitat conservation is crucial to protect amphibian species facing human-induced threats. As we have shown, the habitat of almost half of threatened amphibian species reported herein still remains unprotected and it is likely that at least some of it will be altered in the near future. Climate change, emerging pathogens, air-borne pollution, and invasion of exotic species (e.g., *Lithobates catesbeianus* "bullfrogs") can affect amphibian species inside protected or pristine ecosystems [4,5,12,14,22]. However, other equally important threats such as habitat destruction, water pollution, and illegal collecting can be alleviated by establishing new protected areas. Even though resources to maintain those areas are limited, the establishment of nationally recognized protected areas is the first step towards reducing the risk of local extinction of these species. Locally protected areas, such as municipal reserves or conservation concessions, could be especially appropriate for conserving endemic species. An extensive network of municipal reserves over a broad geographic region can protect a large number of species, for example by conserving specific streamlets or watersheds where an endemic species is known to occur [29]. Locally protected areas require fewer resources than nationally protected areas and could be

monitored by local people (Fig. 6), promoting the involvement of human communities in amphibian and ecosystem conservation and facilitating population management programs where needed. The establishment of private conservation areas (e.g., Huiquilla, Amazonas Region) is also an excellent alternative for conserving target species, and laws to facilitate this process have been recently created [30]. Educational programs and capacity building should be implemented along with the creation of new protected areas, to generate public awareness of conservation issues affecting those areas [30]. Based on our results, the establishment of new protected areas is needed for conserving the habitat of 37 species (Appendices 1 and 2).

Fig. 6. Local people are important partners for long-term conservation initiatives. Field work conducted in many areas in Peru benefits from participation of local personnel trained in field techniques. (a) Recording of standard data and (b) swab sampling for *Bd* screening near Manu National Park, Cusco Region (photographs by E. Biggi). (c) Sampling nocturnal leaf-litter plots at Los Amigos Conservation Concession, Madre de Dios Region (photograph by J.M. Jacobs).

A set of priority areas for conservation in Peru was proposed over a decade ago [31], which was followed by the establishment of several new protected areas by the Peruvian government (currently, 60 nationally-recognized protected areas exist in Peru and cover an area of 19 million hectares or 14.8% of the country's territory [32]). In light of recent research emphasizing the importance of scale for conservation of threatened species [29] and the fact that the Peruvian yungas is a critical ecoregion [10], we propose that the establishment of networks of sites throughout the east Andean versant will be most effective in conserving many of Peru's threatened amphibians. Moreover, since these networks include the headwaters of several river systems, the protection of these sites should benefit human populations by providing a stable water source and by reducing the risk of erosion in downstream areas. Both endemic species with aquatic larvae (e.g., *Atelopus*, *Nannophryne*, *Rhinella*, *Telmatobius*, centrolenids, dendrobatids) and endemic species with terrestrial development (e.g., *Bryophryne*, *Phrynopus*, *Pristimantis*, some *Gastrotheca*) occur in the east Andean versant and will benefit from the protection of these headwaters.

Because chytridiomycosis is a threat to many amphibian populations worldwide [5,16], efforts are being undertaken to determine the incidence of *Bd* on natural populations at different latitudes, elevations, and ecosystems across Peru and neighboring countries [11,19,22,33]. Ongoing projects being conducted at several locations in Peru (A. Catenazzi, J.L. Brown, M.A. Enciso, T.A. Kosch, T. Seimon, unpublished data) will generate important information for understanding the dynamics of *Bd* infection. Moreover, the incidence of bacterial and viral infections should also be taken into account when they are recorded (e.g., *Aeromonas* and other bacteria) in natural populations ([33] and M.A. Enciso, unpublished data).

As was indicated by the Amphibian Conservation Action Plan [5], the long-term success of efforts such as captive breeding programs to recover species from population declines will depend on society's capacity to preserve natural habitats. Captive breeding programs have been proposed as a rapid-response intervention, but it has been suggested that species' fitness can be depressed in the long term (as was shown by an experimental study on trout that were reared in captivity and then released to natural environments for breeding, [34]). Hence, captive-bred amphibians may experience population declines once individuals are reintroduced into their natural habitats. Nevertheless, captive-breeding as part of integrative population management programs could, in principle, be useful as a secondary and complementary conservation action, in particular those cases where the species' biology and requirements are sufficiently well known to increase the chances of program success, and where natural populations may experience over-harvesting (e.g., *Telmatobius* species, *Rhinella limensis*). Individuals at various stages in their life cycle (eggs, larvae, sub adults, adults) should be used when reintroduction of species occurs to increase the chances of that species'
survival and population growth.

Habitat protection should always remain high on the list of priorities for amphibian conservation along with the development of techniques to neutralize or reduce the incidence of pathogen infections and the negative effects of climate change [35]. Outreach and environmental education, especially in areas where amphibian declines are likely to occur, will also be necessary to involve local people in conservation projects and to avoid misunderstandings resulting from different cultural perceptions and the use of natural resources. This is crucial for the maintenance of many protected areas, given that human population growth is much higher near the edge of these areas than in other rural areas [36].

We are aware that we did not include all data on threatened amphibians in Peru because some data are inaccessible as they have been collected for private "environmental assessment" (consulting) firms. Studies for consulting firms result in technical reports submitted by the firms to the Ministry of Energy and Mines in Peru. Less than 30% of these reports have been made available in the official web site of the Ministry of Energy and Mines in Peru [37] (only 110 out of 396 environmental assessment reports conducted between 2000 and 2008 were available for download [37]). In the present study, we did not use available data from privately sponsored environmental assessments because the reports did not go through a formal peer-review process, despite the fact that amphibian data were gathered with standard methods and by qualified personnel. In any event, the consulting firms typically impose policies that prevent authors of these surveys from publishing their data in other outlets (i.e., refereed journals). This is an obstacle to the advancement of knowledge on threatened species, especially in areas where extraction of minerals and fossil fuels pose serious threats to local flora, fauna, and human communities. A new policy should be considered, so that all technical reports (and not only a small fraction) are open to public scrutiny and that relevant information is submitted to peer-review journals.

In conclusion, we suggest that a re-assessment of threatened and non-threatened amphibians in Peru should use standardized criteria established by the IUCN and the GAA as primary sources [3,4]. Additional attributes such as developmental mode could be assigned a numerical value and added to the classification criteria. When applicable, species classified in CITES's Appendix II [26] should also be assigned a numerical value (many species listed in this appendix may become threatened in the future because of the uncontrolled pet trade [26]). In accordance to the Amphibian Conservation Action Plan [5] and the GAA [4], this re-assessment should take into account updated information on species presence/absence, population trends, and the status of their habitat. Field surveys focusing on target species will continue to be crucial in this process.

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Appendix 1. Summary data on threatened amphibian species in Peru. The list includes species in four categories: CR, EN, VU, NT. Region: Región where surveys were conducted in Peru (see caption of Figure 1 for abbreviations). Elevation: elevational range combines published and survey data (* indicates elevational range extension). Protected Area: species occurs inside (Yes) or not inside (No) of natural protected area(s); ~Yes indicates that the species is protected in a private or municipal reserve. Last report: most recent year(s) in which a species was observed. Effort: number of person-days during surveys. Observed N: number of individuals observed. Data from separate years are separated by a / sign. IUCN status and INRENA status indicate the threat categories; none indicates that the species has not been categorized. For *Telmatobius culeus* and *Telmatobius* aff. *marmoratus*, data reported pertain to market surveys in the city of Cusco (see [15]).

Taxon	Region	Elevation (m)	Protected Area	Last report	Effort (pers-dy)	Observed N	IUCN status	INRENA status
Amphignathodontidae								
Gastrotheca excubitor	Cus	3200-3700	Yes	2007/2008	25/32	20/15	VU	none
Strabomantidae								
Bryophryne cophites	Cus	3200-3700*	Yes	2007/2008	25/28	22/33	EN	none
Phrynopus barthlenae	Hua	3420-3770	No	2001/2003	2/2	15/2	LC	none
Phrynopus dagmarae	Hua	3020	No	1998-2000	4	26	CR	none
Phrynopus heimorum	Hua	3420	No	1999/2003	3/1	12/2	CR	none
Phrynopus horstpauli	Hua	3070-3100	~ Yes	1999/2001	10/3	40/15	CR	none
Phrynopus juninensis	Jun	3250-3850	No	2002	10	5	CR	none
Phrynopus kauneorum	Hua	2735-3020	No	2000	5	14	CR	none
Pristimantis cosnipatae	Cus	1300-1800	~ Yes	2008	40	3	EN	none
Pristimantis schultei	Ama	2500-2950	~ Yes	2007	6	5	VU	none
Pristimantis schultei	Ama	2500-2950	~ Yes	2006-2007	30	2	VU	none
Psychrophrynella usurpator[1]	Cus	2800-3600	Yes	2007/2008	25/32	51/34	EN	none
Bufonidae								
Atelopus aff. *andinus*	Hua	1000-2000	Yes	2007/2008	30/15	28/40	CR	none
Atelopus erythropus	Cus	1800-2400	Yes	2004	14	2	CR	none
Atelopus erythropus	Cus	1800-2400	Yes	2007/2008	20/20	0/0	CR	none
Atelopus pachydermus	Caj	2400-2700	Yes	1994	10	8	CR	VU
Atelopus peruensis	Caj	2800-4300*	Yes	1998	8	20	CR	EN
Atelopus peruensis	Anc, Caj	2600-3700	Yes	2002-2007	112	0	CR	EN
Atelopus pulcher	San	600-900	Yes	2007/2008	3/3	16/16	CR	VU
Atelopus pulcher	San	500-1000	Yes	2004-2007	>300	~50	CR	none
Atelopus spumarius	Lor	150-300	Yes	2003-2007	8	~80	VU	none
Atelopus reticulatus	Uca	1200-1600	No	2006	4	0	CR	none
Atelopus tricolor	Cus	1400-2000	Yes	2007/2008	20/20	0/0	VU	none
Nannophryne corynetes	Cus	3010	No	2008	4	0	VU	none
Rhinella chavin	Hua	2600-3070	No	1998-2000	4	35	CR	none
Rhinella aff. *festae*	Hua	100-1700	Yes	2008	45	1	NT	none
Rhinella spinulosa	Cus	4900-5240	No	2005/2008	4/4	57/9	LC	NT
Centrolenidae								
Centrolene hesperium	Caj	1200-3000	No	2006-2007	74	1	VU	VU
Cochranella euhystrix	Caj	1200-3000	No	2006-2007	74	0	DD	VU
Cochranella resplendens	San	550-900	No	2004-2007	>300	1	VU	none
Cochranella saxiscandens	San	850	No	2004-2007	40	0	EN	EN
Ceratophryidae								
Telmatobius arequipensis	Are	1900-4470	Yes	2007	33	57	VU	VU

Appendix 1. Cont'

Taxon	Region	Elevation (m)	Protected Area	Last report	Effort (pers-dy)	Observed N	IUCN status	INRENA status
Telmatobius brevipes	Caj	2000-4300*	No	1998	8	5	EN	NT
Telmatobius culeus	?	3757?	Yes	2007	2	2	CR	VU
Telmatobius marmoratus	Cus	3700-4735	Yes	2008	8	4	VU	none
Telmatobius marmoratus	Cus	4900-5240	Yes	2005/2008	3/3	61/0	VU	none
Telmatobius aff. *marmoratus*	Cus?	3757	Yes	2007	2	~15	VU	none
Dendrobatidae								
Ameerega bassleri	San	200-1300	Yes	2004-2007	>300	>100	NT	NT
Ameerega cainarachi	San	200-800	Yes	2004-2007	>300	~50	VU	NT
Ameerega parvula	Lor	200-1000	Yes	2006-2007	40	34	LC	NT
Ameerega parvula	Ama	200-1000	Yes	2006	24	~100	LC	NT
Ameerega petersi	Pas	200-1400	Yes	2006-2007	20	~50	LC	NT
Ameerega planipaleae	Pas	2000	No	2007-2008	23	11	CR	CR
Ameerega rubriventris	Uca	200	No	2006	3	5	DD	NT
Ameerega simulans	Cus	400-1500	Yes	2005-2006	10	7	LC	VU
Ameerega smaragdina	Pas	200-600	No	2007	2	20	DD	NT
Excidobates mysteriosus	Caj	900-1100	Yes	2005	4	~70	EN	EN
Hyloxalus azureiventris	San	200-1200	Yes	2004-2007	~90	~15	EN	EN
Ranitomeya fantastica	San	200-1200	Yes	2004-2007	>300	~100	LC	NT
Ranitomeya reticulata	Lor	150	Yes	2004-2007	10	~50	LC	NT
Ranitomeya sirensis	Hua	400-1560	Yes	2007	16	2	EN	none

[1] *Psychrophrynella usurpator* was confounded with *Phrynopus peruvianus* in the past; threat information contained in the UICN Red List and Global Amphibian Assessment under *Phrynopus peruvianus* relate to *P. usurpator* (De la Riva, I., Chaparro, J. C. and Padial, J. M. 2008. A new, long-standing misidentified species of *Psychrophrynella* Hedges, Duellman & Heinicke from Departamento Cusco, Peru (Anura: Strabomantidae). Zootaxa 1823: 42-50).

Appendix 2. Summary data on amphibian species likely to be threatened in Peru. The list includes species for which surveys were conducted primarily within the past five years. Region: Región where surveys were conducted in Peru (see Figure 1 for abbreviations). Elevation: elevational range combines published and survey data (* indicates elevational range extension). Protected Area: species occurs inside (Yes) or not inside (No) of natural protected area(s); ~Yes indicates that the species is protected in a private or municipal reserve. Last report: most recent year(s) in which a species was observed. Effort: number of person-days during surveys. Observed N: number of individuals observed. Data from separate years are separated by a / sign. IUCN status and INRENA status indicate the threat categories; none indicates that the species has not been categorized. For *Pleurodema marmotatum*, data pertain to larvae and adults.

Taxon	Region	Elevation (m)	Protected Area	Last report	Effort (pers-dy)	Observed N	IUCN status	INRENA status
Amphignathodontidae								
Gastrotheca atympana	Jun	1540	Yes	2003-2004	5	2	DD	none
Gastrotheca monticola	Ama	1900-3180*	~ Yes	2007	1	1	LC	none
Strabomantidae								
Noblella lynchi	Ama	2500-3500	Yes	2006-2007	30	4	DD	none
Phrynopus ayacucho	Aya	?	No	?	?	2	none	none
Phrynopus bufoides	Pas	3850-4100	No	2001-2002	4	4	DD	none
Phrynopus kotosh	Hua	2950	No	1969	?	6	none	none
Phrynopus oblivius	Jun	3220	No	2005	4	7	none	none
Phrynopus paucari	Pas	3600	No	2002	1	1	DD	none
Phrynopus peruanus	Jun	2005	No	2005	4	4	DD	none
Phrynopus pesantesi	Pas	4390	No	2003	4	9	DD	none
Phrynopus tautzorum	Hua	3770	No	2001	3	2	none	none
Pristimantis cruciocularis	Jun, Pas	1540-1850	Yes	2003	6	22	none	none
Pristimantis flavobracatus	Pas	1770	No	2003-2004	3	5	none	none
Pristimantis melanogaster	Ama	3470	~ Yes	2008	2	2	none	none
Pristimantis ornatus	Pas	2400-3000	No	2000-2004	?	21	none	none
Pristimantis pardalinus	Jun	2640	No	2003	3	16	none	none
Bufonidae								
Atelopus patazensis	Lal	2620	No	1999/2000	<2	5/1	none	none
Rhinella limensis	Lim	<500	No	2002-4/2007	126/22	0/3	LC	none
Rhinella limensis	Ica	<500	No	2002	1	1	LC	none
Centrolenidae								
Cochranella chancas	San	1080-1100	No	2005	2	3	DD	none
Cochranella croceopodes	San	200-800	No	2004-2007	20	>50	DD	none
Hyalinobatrachium lemur	San	500-1080	No	2004-2007	20	3	DD	none
Ceratophryidae								
Telmatobius atahualpai	Lal, San	2600-4000	Yes	1999/2000	54/36	0/1	DD	none
Telmatobius timens	Cus	3400-3700	Yes	2007/2008	25/28	0/0	DD	none
Dendrobatidae								
Ameerega macero	Jun	150-1560	Yes	2006-2007	10	10	LC	none
Ameerega pongoensis	San	200-450	No	2005-2007	20	~30	DD	none
Ameerega silverstonei	Hua	1200-1600	Yes	2006	15	8	DD	none
Excidobates captivus	Ama	200-500	Yes	2006	40	17	DD	none
Ranitomeya benedicta	Lor, San	150-400	Yes	2008	68	14	none	none
Ranitomeya biolat	Mad	250-1200*	Yes	2007	3	20	LC	none
Ranitomeya flavovittata	Lor	150	Yes	2003-2004	6	20	DD	none

Appendix 2. Cont'

Taxon	Region	Elevation (m)	Protected Area	Last report	Effort (pers-dy)	Observed N	IUCN status	INRENA status
Ranitomeya imitator	San	200-1200	Yes	2004-2007	>300	>500	LC	none
Ranitomeya lamasi	Hua	150-1400	Yes	2006-2007	20	~50	LC	none
Ranitomeya summersi	San	300-690	No	2008	7	12	none	none
Ranitomeya uakarii	Lor	150-200	Yes	2003-2007	1	15	none	none
Ranitomeya vanzolinii	Cus	200-1280	No	2005	25	4	LC	none
Leiuperidae								
Pleurodema marmoratum	Cus	4900-5400	Yes	2005/2008	4/4	2619/187	LC	none
Rhinatrematidae								
Epicrionops bicolor	Cus	420-?	Yes	2006	18	1	LC	none
Caeciliidae								
Oscaecilia bassleri	San	100-800	No	2006	90	2	LC	none
Siphonops annulatus	San, Mad	150-800	~Yes	2006/2008	90/>100	1/1	LC	none