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Amphibian Declines in Latin America: Widespread Population Declines, Extinctions, and Impacts[1]

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ABSTRACT

Amphibian populations are in decline throughout Latin America; all families of frogs have experienced declines, but the species associated with aquatic habitats in upland areas have been most affected. Declines in Latin America were most common during the 1980s, but new declines continue to be reported. The causes of declines are varied, but they have most often been associated with habitat loss, a pathogenic fungus, and climate change. Scientists are just beginning to grasp the ethical and biological implications of losses of this magnitude. In this Special Section, we provide a general summary of the phenomenon and introduce five contributed papers that provide new data and new insights into Latin American declines.

RESUMEN

En América Latina se ha documentado un declive generalizado en poblaciones de anfibios. Dicho declive se ha presentado en especies de todas las familias de anfibios, pero especialmente en aquellas asociadas a ambientes acuáticos en zonas montañosas. El declive en América Latina, ocurrió en la década de los 80s, pero en la actualidad todavía se siguen registrando disminuciones. Los investigadores apenas están empezando a a entender las implicaciones éticas y biológicas de pérdidadas de biodiversidad de esta magnitud. Aquí presentamos un resumen general de este fenómeno y la introducción a cinco trabajos que proveen datos nuevos para América Latina.

Key words: amphibians; climate; declines; disease; extinction; habitat; Neotropics; population.

AMPHIBIAN POPULATIONS BEGAN TO DECLINE AND DISAPPEAR FROM MANY COUNTRIES around the world as early as the 1950s (Houlahan *et al*. 2000). However, it was not until the first World Congress of Herpetology in 1989 that numerous anecdotal stories of declining amphibian populations convinced scientists that this phenomenon was real. By the late 1990s, several well-publicized population die-offs, apparent extinctions, and declines of entire amphibian faunas from Latin America were described (Heyer *et al.* 1988; Weygoldt 1989; Pounds and Crump 1994; Lips 1998, 1999). Since that time, additional statistical analyses (Pounds *et al.* 1997, 1999; Alford and Richards 1999; Lips *et al.* 2003; Ron *et al.* 2003), long-term monitoring programs (Pearman *et al.* 1995, Joglar & Burrowes 1996, Pounds *et al.* 1997), and experimental investigations (Woodhams *et al*. 2003, Piotrowski *et al.* 2004) have served to convince the scientific establishment that amphibian decline is indeed a global phenomenon.

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Most recently, Stuart *et al.* (2004) reported on the status of amphibian species around the globe. They found that 43 percent of the amphibian species are experiencing some form of population decrease, 32.5 percent of the species are globally threatened, and that 122 species are possibly extinct; most of those losses are recent, having occurred since 1980. They also found that the geographic distribution of rapidly declining species was non-random, with neotropical species more affected than species from other areas. Most reported neotropical declines occurred in the protected montane areas without obvious causes, which they dubbed "enigmatic" declines.

Amphibian population data from the tropical regions of Africa and Asia are limited (but see Voris & Inger 1995) and there are no reported die-offs or enigmatic population declines from either area (Weldon *et al.* 2004). Stuart *et al.* (2004) found that over-exploitation for the food industry was the major threat to Asian amphibians, and habitat loss was the primary contributor to losses of African amphibians. In contrast, researchers working in neotropical regions have made significant contributions to our general knowledge of amphibian declines. Latin America is an active zone for the studies of amphibian declines, has many scientists, and some of the most thoroughly documented declines in the world. For some regions of Latin America, there are extensive museum collections and reasonably complete faunal inventories that are available to provide historical samples and to compare changes over time *(e.g.,* Ron *et al.* 2003, Burrowes *et al.* 2004, Lips *et al.* 2004). A few areas have contributed data from long-term population studies of a few species (*e.g.,* Vial 1968, Stewart 1995) or communities (*e.g.,* Caldwell 1974, Crump 1974). Young *et al.* (2001) compiled information from Latin American experts and concluded that at least 13 countries had experienced declines and in 40 cases the species were thought to be extinct or extirpated in a country where they once occurred. Collectively, these studies have provided baseline data on species richness, population abundance, and variation in those factors; these are precisely the kinds of data that are lacking for most tropical areas in Africa and Asia. Despite the substantial progress that has been made in studying amphibian declines in the Neotropics, we note that declines are still occurring, knowledge of the phenomenon across the entire region remains incomplete, and preventative measures are lacking.

The Research and Analysis Network for Neotropical Amphibians (RANA) was founded in May 2002 in response to successful efforts to establish standard amphibian monitoring methods among Latin American scientists (Lips *et al*. 2001, Young *et al*. 2001). Currently over 80 RANA members in 16 neotropical countries, Germany, UK, and the United States work toward promoting understanding about amphibian population declines through collaborative research. Much progress has been made in understanding the causes and patterns of amphibian population declines in the Neotropics. We present here a series of papers representing collaborations among RANA members that highlight the contributions from Latin American scientists and collaborators.

The five papers included here greatly increase our knowledge of the geographic extent of amphibian declines. Despite the high species richness of Brazilian amphibians (>650 species), the diversity of habitats, and the strong infrastructure of Brazilian science, remarkably few reports document amphibian population declines from Brazil. Eterovick *et al.* (2005) summarize what is known of the declines throughout the country, extending our knowledge of amphibian declines from the *Mata Atlantica* (*e.g.,* Heyer *et al.* 1988, Weygoldt 1989) into additional regions (Ceará, Paraná) and habitats (cerrado) where population declines are suspected. In a thorough examination of the literature, museum specimens, and personal interviews, Eterovick *et al*. (2005) found evidence that 30 species are experiencing some form of decline, but emphasize that this represents a handful of well-studied sites and species and that additional exploration will likely increase the number of threatened species and habitats in this country.

Some of these papers expand our knowledge of the number of taxa affected. Ecuador has long been a shining example of a concerted effort to document national biodiversity. Bustamante *et al.* (2005) compared historic data from museum records and field notes with current surveys of amphibian diversity at seven different sites across the Andes. The degree of loss they describe is astounding, with six of the seven sites showing significantly reduced species richness and 56 of the 88 populations at lower abundance today than in the past. All this, in spite of the greater efforts devoted to recent surveys. Also of interest are the ecological differences found between those species that persist and those that have declined or disappeared. Bustamante *et al.* (2005) found that only 17 of the 34 species that have aquatic larvae persisted at these sites, while 24 of the 25 species that have direct development and lack aquatic larvae endured. Their regional evaluation of amphibian communities shows that these are not isolated losses, but are points within a broad swathe of the Ecuadorian Andes that no longer contains healthy amphibian communities.

Similarly, the international collaboration that produced a genus-wide evaluation of species of *Atelopus* also greatly expands our appreciation for the extent of declines within particular groups. LaMarca *et al.* (2005) gathered data from experts throughout Latin America into a database that provides the most thorough description of the status of all *Atelopus* species and evidence of population declines and potential causes. About half of the 113 species of *Atelopus* have either declined or disappeared, 32 species have not been seen in the last five years and may be extinct, and only ten populations are known to be doing well. At least nine declining species have been infected with the frog-killing fungus *Batrachochytrium dendrobatidis,* and the authors suspect that this disease might be a much greater threat than is currently documented. The authors posit that the status of these brightly colored, abundant, diurnal toads might also indicate the status of other, less-studied, cryptic, nocturnal species at these sites. If this is the case, then the situation may be desperate for a large portion of Latin American amphibians (*e.g.,* Stuart *et al.* 2004).

As important as it is to document the current taxonomic and geographic patterns of amphibian declines, effective conservation measures demand predictive power in estimating future trends. Two papers describe models of how climate change might interact with habitat loss. Parra-Olea *et al*. (2005) use environmental modeling to predict how climate will change in the future as a result of both global warming and deforestation in Mexico, and model how two species of plethodontid salamanders would respond. This paper is important because, like Brazil and Ecuador, Mexico is a biodiversity hotspot, with over 318 species of amphibians described, but with few reports of amphibian declines. As a result, reports from even a few sites in these countries are certain to increase the number of impacted amphibians. Also, as has been shown elsewhere (Stuart *et al.* 2004, LaMarca *et al.* 2005, Eterovick *et al.* 2005), habitat loss is still the major cause of extinction for all organisms, including amphibians.

Ron (2005) provides another example of predictive modeling, in which global temperature and rainfall patterns are analyzed and then overlaid on the predicted distribution of *B. dendrobatidis*, based on the conditions of sites at which it has already been found. This model gives scientists and managers a powerful tool that indicates not only where to go and search for this frog-killing fungus, but also a series of "control" sites that should be inhospitable to the fungus and where it is not expected to occur. A careful search of both areas should result in much greater confidence in the natural distribution of *B. dendrobatidis*, greater understanding of the natural environmental limits of this fungus, and insights into how certain species and areas do not seem to be affected by this organism while others are devastated.

This selection of papers serves as a series of case studies focused at different scales (genus, site, country, region) but which collectively highlight the perilous condition of Latin American amphibians. The areas represented in this special section are some of the most important biodiversity hotspots in the world (*e.g.,* Brazil, Mexico, Ecuador), and contain over 1401 described species of amphibians. Most of these studies are necessarily restricted to particular habitats, areas, or taxa; but if we use these examples as indicators of the status of other areas or taxa, we must conclude that as a group, Latin American amphibians are under serious threat of extinction.

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