CHAPTER 9. AMPHIBIANS OF THE NEOTROPICAL REALM

Coahuilla vazquezi (Dilys Vences) is a poorly known species endemic to Cerro El Hame, in the Poncida de Paris, in northern Venezuela. It is a glass frog from the Family Centrolenidae that inhabits tropical humid forests, along streams. It lays its eggs on the upper side of leaves overhanging streams. The larvae fall into the stream below after hatching. © Juan Manuel Guayasamin

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THE GEOGRAPHIC AND HUMAN CONTEXT

The Neotropical Realm includes all of mainland South America, much of Mesoamerica (except parts of northern Mexico), all of the Caribbean Islands, and extreme southern Texas and Florida in the United States.

The geology of Mesoamerica is very complex and still not completely understood. The land north of the Isthmus of Tehuantepec in southern Mexico is historically part of the North American continent, with the highest point of the Isthmus of Tehuantepec at 500m asl. The land south of the Isthmus to the southern Nicaraguan lowlands is a mosaic of plateaus that have rearranged themselves and ultimately been submerged and exposed by the sea several times during the past 50 million years. The region encompassed by Panama, Costa Rica, and southern Nicaragua formed over the last three to ten million years through a combination of volcanic activity and uplift. The result is a jumble of mountain ranges interrupted by valleys and lowlands, with the highest point being Volcan Tamaulipas at 4200m asl in Guatemala.

The closing of one of these blocks of land in present-day Nicaragua during the Pleocene (5-3, 1.8 Ma) has had a marked impact on the distribution of amphibians.

The geological history of the Caribbean also remains under intense study, but most geologists now agree that the Greater Antilles (Cuba, Jamaica, Hispaniola, and Puerto Rico) are a geologic northern Central America. Some 160 Ma, these islands were lined up more or less between North and South America in approximately the location of present day Central America. Over the last 70 million years, these islands have drifted eastward to their current positions. The trailing edge of this parade of islands has fused to North America and now makes up northern Central America. Some of the Greater Antilles may have had temporary land connections with North and/or South America as the taxonomic status of many species complexes is resolved.

A total of 2,916 amphibian species (48% of the world’s total) are recorded from the Neotropical Realm, of which 1,376 (99%) are considered to be globally threatened (Figure 9). This is significantly more than the global average of 32%. As the case globally, the percentage of threatened species is expected to increase as the status of C0 species is clarified, as new species (some of which are likely to be rare, and/or have small ranges) are discovered, and as the taxonomic status of many species complexes is resolved.

Table 1. The Critically Endangered (Possibly Extinct) amphibian species in the Neotropical Realm. *species that also occur in the Nauru Archipelago. A full list of C0 species can be found in Appendix IX.

![Figure 1. Summary of Red List categories for amphibians in the Neotropical Realm.](#)
The Neotropical Realm contains 67% (1,413) of all globally threatened amphibians. The region accounts for 30% of species, 59% of the EN species, and 49% of the VU species in the world. In other words, unlike the case elsewhere, threatened Neotropical amphibians are more likely to be in a higher category of threat (CR or EN) when compared with the global distribution of threatened species. Important exceptions are the extreme high elevations (above 2000m asl), the typical ecological profile of species that have experienced rapid declines (Lips et al., 2003; Ron et al., 2003; Burrowes et al., 2004; Stuart et al., 2004; La Marca et al., 2005). Some additional undescribed species are possibly extinct, especially in the genus Atelopus (see Pounds et al., 2005). In addition, 127 critically endangered species in the Neotropics are considered possibly extinct. This represents 9% of the 1377 possible extinctions in the world, suggesting that this region is facing an extinction crisis that has unfolded with the Neotropical amphibians. Most of the Critically Endangered (Possibly Extinct) species listed in Table 1 share the same ecological characteristics as those that have gone extinct. Of the 127 possibly extinct species, 72 are terrestrial taxa in the genus Atelopus (representing 29% of the described species in the genus), which have experienced catastrophic declines, especially in southern Mesoamerica, and in the Andes south at least to Peru (La Marca et al., 2005; Pounds et al., 2005), and see Essay B. Ten genera concentrated in Mesoamerica also have large proportions of possibly extinct species: Aplastodryma (10%), Eleutherodactylus (10%), Craugastor (14%) and Thorius (17%) (see, for example, Lötters et al., 2004 and Mendelson et al., 2004). In addition, the endemic genus Cycloramphus (2004) et al. (2004, 2006) and Mendelson et al. (2004) is possibly extinct. Another genus for which the percentage of possibly extinct species might have been understudied is Cyclorana from southern Brazil (see Diallo et al., 2005 for more details). The genus Rhinoderma (which occurs in the Andes from Ecuador southwards) is also subject to extensive disappearances, but much of this information is only just now becoming available, and in the most part is not very widely known. There are 21 species. Many species occur in the Andes on the western slopes, and many others occur on the eastern slopes, including the Andes in Ecuador and Peru (Pounds et al., 2005), and see Essay B. Possibly extinct species range very widely in the Neotropics, generally in montane regions from southern Mexico (for example, Ambystoma tigrinum occurs in the highlands of southern Mexico) to the southern Andes (for example, Xiphophorus vigilax occurs in the Andes in Ecuador). A number of recent declines and possible extinctions in Colombia have come to light since the GAD data were collected (F. Castro pers. obs.).

**Species Richness and Endemism Across Taxa**

Of the 2,816 native amphibians species in the Neotropical Realm, 2,069 (74%) are endemic to the Neotropics (Table 2). All three orders of extinct species are listed in Table 1. The overwhelming majority of Neotropical amphibians (89%) are frogs and toads (Anura), 10% of which are endemic. All species of Neotropical caecilians (Gymnophiona), and 87% of Neotropical salamanders (Caudata), are endemic. Only 382 species (14%) are members of families that are endemic to the region, but this low percentage is really a reflection of the fact that the very large family Leptodactylidae (accounting for 42% of Neotropical amphibian species) marginally occurs in the Neotropical Region.

**Figure 2.** The species richness of amphibians in the Neotropical Realm, with darker colours corresponding to regions of higher richness. Colour scale based on 10 quantile classes; maximum richness equals 144 species.
Figure 3. a) The richness of threatened amphibians in the Neotropical Rainforest. b) The richness of threatened amphibians in the Neotropical Rainforest.

Table 3. The number of species within each IUCN Red List Category in each family and Order in the Neotropical Rainforest. Introduced species are not included.

<table>
<thead>
<tr>
<th>Family</th>
<th>EN</th>
<th>CR</th>
<th>VU</th>
<th>NT</th>
<th>LC</th>
<th>DD</th>
<th>Total number of species</th>
<th>Number Threatened or Extinct</th>
<th>% Threatened or Extinct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anura</td>
<td>5</td>
<td>8</td>
<td>11</td>
<td>20</td>
<td>15</td>
<td>15</td>
<td>86</td>
<td>28</td>
<td>33%</td>
</tr>
<tr>
<td>Amphibia</td>
<td>44</td>
<td>10</td>
<td>23</td>
<td>50</td>
<td>40</td>
<td>45</td>
<td>237</td>
<td>63</td>
<td>27%</td>
</tr>
<tr>
<td>Gymnophiona</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>TOTAL ANURA</td>
<td>5</td>
<td>8</td>
<td>11</td>
<td>20</td>
<td>15</td>
<td>15</td>
<td>86</td>
<td>28</td>
<td>33%</td>
</tr>
<tr>
<td>TOTAL AMPHIBIANS</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>
As with other parts of the tropics, Figure 2 probably does not reflect genuine patterns of amphibian species richness everywhere in the region, due to uneven survey effort. In particular, species richness is probably under-sampled in the Guianan Shield, in the Venezuelan Llanos, the Guinean Forest, and some lowland areas of the Peruvian and Bolivian Andes, and in the Cerrado of Brazil. However, sampling appears to be less uneven than in the Old World tropics (similer maps for the Afrotropical, Indomalayan and Australasian realms make much less overall biogeographic sense). New species continue to be discovered at a rapid rate almost everywhere in the Neotropics, but nevertheless the overall patterns of species richness are probably reasonably clear.

Over 85% of the threatened amphibian species in the Neotropics occur in the region from southern Mexico to Ecuador and northern Venezuela, and on the Greater Antilles (Cuba, Hispaniola, Jamaica and Puerto Rico) (see Figure 36). This region represents by far the greatest concentration of threatened amphibian species anywhere in the world. Within this region there are peaks of threatened species in montane areas in southern Mexico, Guatamala, Honduras, Costa Rica, western Panama, Cuba, Hispaniola, Jamaica, Puerto Rico, and the Andes of Venezuela, Colombia and Ecuador. Outside this region, the largest concentration of threatened amphibian species in the Neotropics is in the Atlantic Forests of southern Brazil. There are lesser concentrations in the Peruvian and Bolivian Andes, and in the austral forest zone of Chile. It is possible that, due to the poor state of knowledge, the levels of threat have been under-estimated in the Peruvian and Bolivian Andes, further, with very recent records in some places. In Argentina (see Rivas 2002), and probably in other species too, not yet included in our data, it is likely that a new concentration of threatened species will soon be identified in the Andes running from Peru south to Bolivia, Chile, and Argentina. These concentrations of threatened species correlate with those for other taxa (Ballie et al. 2004). These geographic concentrations reflect the topographically diverse areas of the region where amphibians have relatively small ranges, and where habitat destruction is ongoing (and in central and southern Peru is in part a reflection of the over-harvesting of some frogs (e.g., in the genus Leptodactylus) for human consumption). However, these are also the places where amphibians are most widespread and disappearances have been noted due to chytridiomycosis. A more detailed study (Heyer et al. 1993; Lee and McDiarmid 1993; Young et al. 2001; Lepage 2003, 2004, 2006; Pan et al. 2003; Balmaseda et al. 2004; Mendez et al. 2004; Da Iva 2004; Estavrich et al. 2002; McDiarmid et al. 2002, Pounds et al. 2006).

The concentrations of Critically Endangered species (Figure 38) broadly match those of threatened species as a whole. The greatest concentrations of these most severely threatened species are in southern Mexico (in particular Veracruz and Oaxaca), Colombia, Ecuador, the Guianan Shield, and the Andes of South America (especially the Massif of La Grande and Massif de la Selle). Lesser concentrations of Critically Endangered species are found in the Andes of Venezuela, Colombia, Peru, southern Brazil, central Chile, Puerto Rico, Dominican Republic, Jamaica, and eastern Cuba (although recent data from the Colombian Andes suggest that the next update of the GMA might reveal this region to be a major concentration of Critically Endangered species (see Castro pers. com.).

Species Richness and Endemism within Countries

Amphibians occur naturally in every mainland country in Mesoamerica and South America, and on all but the smallest Caribbean islands (Figure 4). However, only one extant species occurs naturally in St. Lucia, St. Kitts and Nevis, the Netherlands Antilles, Barbados and Anguilla, and only two on Antigua and Barbuda, the Bahamas, the Cayman Islands and Montserrat. There are no indigenous amphibians on the Galápagos Islands.

The two countries with the largest numbers of species in the Neotropical Realm are Brazil (751 species; see Essay 4) and Colombia (687 species; see Essay 9). There is also very high species richness in Ecuador (444 species; see Essay 11), Mexico (330), Venezuela (309) and Bolivia (286). Brazil, Colombia, Ecuador, Peru, and Mexico are the top five countries in the world in terms of amphibian species richness. Another eight Neotropical countries have more than 130 species: Argentina (153), the Massif de la Hotte and Massif de la Selle (126), Argentina – 126, Argentina – 118, Argentina – 112, Bolivia – 118, Bolivia – 116, French Guiana – 104, Suriname – 103.

These figures are, of course, a reflection of current knowledge, and as mentioned earlier, certain regions have been better studied than others. In certain places, the existing knowledge has been well summarised in review literature, and in books, including: Mexico (Flanco-Villers 1983; Rao-Villers et al. 1991; Calderon Mandujano et al. 2000), Yucatan (Campbell 1988b; Lee 1998, 2000), Guatemala (Lee 2000, Campbell 1999b, 2010), Bolivia (Campbell 1998b, Lee 2003; Hudsons, Flyer and Wilson 2002; McFarlane 2006; T Schuckor [Köhler et al. 2002, Neoceratos (Waller 2001; Costa Rica Savages 2003; Gayer and Donnelly 2005); Panama (Blech et al. 1996, 2000); Colombia (Pazo Corredura et al. 1996), Venezuela (La-Me 1992, 1997; Barrion 1998); Ecuador (Coloma 2003, Peru (Luft 2002; Bolívar de la Hoya et al. 2000, 2002; Bain 2004; Argentina (Cali 1996, 1997; Lafaille et al. 2003; Lafaille and Dain 2001); Chile (Niebao and Narvano 1998, Formas 1998; Brasil (Sorace and Brasil (2004); the Guianas (Magliozzi 1979); the Guianas (Skeels and MacCulloch 1999); French Guiana (Lescure and Marty 2000), the Caribbean islands (Heyer 1998; Schwartz and Henderson 1998; Powell and Henderson 1998; The Lesser Antilles (Mahayana and Torrens 1998; Guadeloupe (Brist 2002; Netherlands Antilles (Powell et al. 2006; van Buitst 2005); Trinidad and Tobago (Muybridge 1965). There have also been some important reviews of particular taxonomic groups, for example on the Myobatrachidae (Duellman 2001), on the western distribution of Neotropical salamanders (Lynch and Duellman 1997), and Neotropical plethodontid salamanders (Wake and Lynch 1997; Wake 2003).

Brazil has more endemic species (496) than any other country in the Neotropics (Figure 4), or in the world, followed by Colombia (234), Peru (181), Ecuador (159), and Venezuela (155). More than 50 endemic species are also known from Cuba and the Bahamas. In terms of percentage of the fauna being endemic, the highest endemism is in the Greater Antilles (Figure 33), with Jamaica at 40%, Cuba at 84%, and Puerto Rico at 78%. Although the percentage endemism in Haiti and the Dominican Republic is lower, the island of Hispaniola as a whole it is 100%. On the mainland the highest percentage endemism is found in Mexico (60%), Costa Rica (80%) and Brasil (85%) with levels over 40% in Venezuela, Haiti, Guadeloupe, Colombia, and Peru (Figures 5). Threatened species occur in 31 of the 44 countries in which there are native amphibians (Figure 6). In fact, threatened species are concentrated in relatively few countries. Colombia has more threatened amphibian species than any other country in the Neotropics (2000), followed by Mexico (136), Ecuador (126), and Brazil (116). A further 12 countries have 20 or more threatened species: Peru, Guatemala, Venezuela, Costa Rica, Panama, Honduras, Cuba, Haiti, Dominican Republic, Argentina, Bolivia, and Chile. This percentage of threatened amphibian species is highest in the Greater Antilles (Figure 7), with Haiti at a staggering 92%, the Dominican Republic at 86%, Jamaica at 81%, Cuba at 80% and Puerto Rico at 72%. Overall, the percentage threat levels for amphibians on the Caribbean Islands are worse than anywhere else in the world, and is a reflection of the very poor state of habitat conservation, coupled with chytridiomycosis in some places (see Essay 9) (of course, in these relatively species-poor countries, even a limited number of threatened species can result in a high percentage of species at risk of extinction). The highest percentage of threatened species on the mainland is in Mexico (57%), closely followed by Guatemala (54%), with a further 12 countries having levels greater than 30%. Guadeloupe, Dominica, and Puerto Rico have the highest levels of threat in Central America, at 100%, 95% and 80% respectively.

Figure 4. The number of amphibian species and endemic to each Neotropical country *Denotes countries not entirely within the Neotropical Realm, hence only the species whose ranges fall within the region are included.

Figure 5. Percentage of species endemic to each Neotropical country *Denotes countries not entirely within the Neotropical Realm, hence only the species whose ranges fall within the region are included.

Figure 6. The number of threatened amphibians present in each endemic to each Neotropical country. Countries with no threatened spe-
cies are not included in the diagram. *Denotes countries not entirely within the Neotropical Realm, hence only the species whose ranges fall within the region are included.

Figure 7. Percentage of native species that are threatened. Countries with no threatened spe-
cies are not included in the diagram. *Denotes countries not entirely within the Neotropical Realm, hence only the species whose ranges fall within the region are included.
Some countries have particularly high proportions of Critically Endangered species. The most extreme example is Haiti, where 31 species are CR, 19 are EN and nine are VU (out of a total amphibian fauna of 50 species). In the neighbouring Dominican Republic, the situation is marginally less severe (15 CR, 10 EN, 5 VU out of 36 species), though still very serious. Puerto Rico has 7 CR, 5 EN and 1 VU (out of a fauna of 18 species). On the mainland, things are particularly bad in Honduras (31 CR, 24 EN, 19 VU, out of 116 species), and also very disturbing in Chile (20 CR, 4 EN, 7 VU out of 56), Mexico (69 CR, 60 EN, 41 VU out of 359), Guatemala (17 CR, 30 EN, 19 VU out of 140), and Costa Rica (19 CR, 22 EN, 20 VU out of 178). In general, the levels of threat are worse in Mesoamerica than South America, because habitat loss has in general been more severe in the former, and also chytridiomycosis has been especially severe in this region (see Essay 9.7). The situation is also serious and deteriorating in the Andean countries, where there is also significant habitat loss, and chytridiomycosis is currently spreading (Cao et al. 2006; La Marca et al. 2006). However, because most of the Andean countries also have large, intact Amazonian amphibian faunas, the percentage of threatened species is not usually as high as in some of the Mesoamerican countries. The percentage of threatened species in Peru and Bolivia is almost certainly underestimated due to paucity in knowledge.

HABITAT AND ECOLOGY

Habitat Preferences

Most Neotropical amphibians (86%) occur in forests, and only just over 20% can survive in secondary terrestrial habitats (Table 4, Figure 8). Compared with Allopatric species, for example, Neotropical amphibians appear to be less able to survive in disturbed areas. They also appear to make more use of flowing water habitats than still, open freshwater habitats, or marshes and swamps. This is presumably a reflection of the great diversity of stream-associated species in the Andes and Mesoamerica. Forest-dwelling amphibians are more likely to be threatened than those occurring in any other terrestrial habitats, with over 40% of them being globally threatened. A similar percentage of amphibians associated with flowing water (generally streams) is threatened. Forest-associated amphibians that live along streams are particularly likely to be threatened, a combination that has also been associated with rapid declines worldwide (Durant et al. 2004).

The percentage of threatened species varies considerably between different types of forest. In montane tropical forest, over 50% of known species are threatened, compared with just over 30% in lowland tropical forest. These figures probably reflect smaller range sizes of montane species, the lack of effective habitat conservation measures in many montane parts of the region, and the high incidence of chytridiomycosis in montane areas (Daug et al. 2003; Burrowes et al. 2004). Amphibians occurring in savannahs, marshes and swamps, still open freshwater habitats, and secondary terrestrial habitats are much less likely to be threatened than those occurring in other habitats (Table 4, Figure 8).

Reproductive Modes

Of those species where reproduction is known or reasonably inferred, larval development is the most common reproductive mode in the Neotropics (58% of species), compared with 39% for direct development and 1% live-bearing (this compares with the global picture of 68% larval development, 30% direct development, and 1% live-bearing [Table 3]). The Neotropical

Table 4. The habitat preferences of amphibians in the Neotropical Realm. (Continued)

<table>
<thead>
<tr>
<th>Habitat type</th>
<th>Number of species in each habitat</th>
<th>% of all species occurring in the habitat</th>
<th>Threatened or Extinct species</th>
<th>% of species occurring in habitat that are Threatened or Extinct</th>
</tr>
</thead>
<tbody>
<tr>
<td>All tropical forest</td>
<td>2,457</td>
<td>65</td>
<td>1,503</td>
<td>44</td>
</tr>
<tr>
<td>All non-tropical forest</td>
<td>1,551</td>
<td>56</td>
<td>648</td>
<td>42</td>
</tr>
<tr>
<td>Lowland tropical forest</td>
<td>1,450</td>
<td>48</td>
<td>472</td>
<td>32</td>
</tr>
<tr>
<td>Montane tropical forest</td>
<td>1,941</td>
<td>53</td>
<td>929</td>
<td>48</td>
</tr>
<tr>
<td>Rainforest</td>
<td>200</td>
<td>7</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Grassland</td>
<td>429</td>
<td>15</td>
<td>176</td>
<td>28</td>
</tr>
<tr>
<td>Wetland</td>
<td>345</td>
<td>12</td>
<td>34</td>
<td>10</td>
</tr>
<tr>
<td>Secondary terrestrial habitats</td>
<td>672</td>
<td>25</td>
<td>116</td>
<td>18</td>
</tr>
<tr>
<td>Flowing freshwater</td>
<td>1,119</td>
<td>38</td>
<td>568</td>
<td>45</td>
</tr>
<tr>
<td>Montane wetland</td>
<td>460</td>
<td>16</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>Still open freshwater</td>
<td>746</td>
<td>26</td>
<td>116</td>
<td>16</td>
</tr>
<tr>
<td>And and semi-wet habitats</td>
<td>21</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 5. Neotropical amphibians categorized by reproductive mode.

<table>
<thead>
<tr>
<th>Reproductive mode</th>
<th>All species</th>
<th>Threatened or Extinct species</th>
<th>% Threatened or Extinct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct development</td>
<td>1,119</td>
<td>514</td>
<td>46</td>
</tr>
<tr>
<td>Live-bearing</td>
<td>1,715</td>
<td>671</td>
<td>39</td>
</tr>
<tr>
<td>Not known</td>
<td>68</td>
<td>5</td>
<td>7</td>
</tr>
</tbody>
</table>

Major Threats

Habitat loss is overwhelmingly the major threat to amphibians in the Neotropics (Table 8, Figure 8), affecting nearly 90% of the threatened species. The two other most commonly recorded threats are pollution and disease (both affecting nearly 30% of threatened species). With the exception of fire (17%), all other threats are of minor importance. Over-utilization appears to be a minor threat in the region as a whole (at least, based on current knowledge), but it can have a serious impact on some species (e.g., on the genus Eleutherodactylus in Caribbean montane forests).

The distribution of chytridiomycosis in the Neotropics is only gradually becoming clear. Ron (2003) documented confirmed records of the disease widely in Mesoamerica (southern Mexico, Guatemala, Costa Rica, Panama), the Caribbean (Dominican Republic, Puerto Rico), and north-western South America (Ecuador, Venezuela). More recently the
disease has been recorded more widely in the continent, for example in southern Peru (Seim et al. 2005), southern Brazil (Carvalho et al. 2005) and the Pampas region of Argentina (Haines et al. 2005). The earliest records of the fungus in the region date from the early 1980s, and coincide roughly with the onset of amphibian declines (Carvalho et al. 2006; Lips et al. 2006).

A total of 181 species are recorded as being used for some or other purpose in the region (85 of which are threatened through not necessary by use and one now considered Extinct). The most common reason for harvesting Neotropical amphibians is for the international pet trade, followed by local human consumption (Table 8). Well-known examples of utilization in the region include the pet trade in colourful, poikilospermous frogs in the genera Eleutherodactylus, Epipedobates and Phyllobates, and the homed frogs (in the genus Cochranella), and harvesting Telmatobius frogs for local human consumption in parts of the Andes. Much of the harvesting of amphibians in the region is not considered to constitute a major threat to the species, but there are exceptions (for example the case of several species of Ambystoma). Of the 180 extant species being harvested, utilization is considered to be a major threat for 74 (of which only 40 are threatened species for which harvesting is believed to be contributing to deterioration in their status).

**POPULATION STATUS AND TRENDS**

**Estimates of Population Trends**

A summary of the inferred population trends of Neotropical amphibians is presented in Table 8. In the absence of more rigorous population monitoring studies, these trends are largely inferred from trends in the state of the habitats on which the species depend (though in some cases, dramatic population declines have been noted). Species with declining populations are typically forest-dependent species that can tolerate little disturbance to their habitats. The overall trends of Neotropical amphibians are very similar to the global results.
**Threatened Amphibians of the World**

Bolitoglossa psammota (findelgangi) is a limpet salamander from the family Plethodontidae, and is restricted to the Cordillera de Segoviana in Costa Rica. It still occurs in many places within its range, but has drastically declined in some sites where it was formerly abundant, while appearing to be stable in others. © Twan Leenders

**KEY FINDINGS**

- A total of 3,810 species are recorded from the Neotropical Realm, of which 1,145 (30%) are considered critically endangered, and 3,665 (96%) are listed as “threatened”.
- At the species level, 2,803 amphibians (96% of those present) are endemic to the Neotropics - a robust half of all recognized amphibians worldwide, of the 20 families found in the region, six are endemic, and of 181 amphibian genera occurring, 157 are endemic.
- The percentage of threatened species is very high in the families Phrynosomatidae (100%), Anaxyrus (80%), Eleutherodactylidae (78%), and Strabomantidae (63%).
- Geographical concentrations of threatened species occur in the Greater Antilles (Cuba, Hispaniola, Jamaica, Puerto Rico, Hispaniola, and other small islands), the Amazon basin (Brazil, Colombia, Peru, and Bolivia), the Andes (especially in Colombia and Ecuador), and the Caribbean (especially in Puerto Rico and the Dominican Republic).
- Brazil has the largest number of species in the Neotropical Realm (793 species), and has more endemics than any other country (483). Thirteen other countries have more than 100 species (Columbia, Ecuador, Peru, Venezuela, Bolivia, Panama, Costa Rica, Argentina, Guatemala, Guyana, Honduras, French Guiana, and Suriname), with the first five of these countries having more than 200 species.
- Colombia has the largest number of threatened species (309), followed by Mexico (198), Ecuador (171), and Brazil (117). Peru, Guatemala, Venezuela, Costa Rica, Panama, Honduras, Cuba, Haiti, Dominican Republic, Argentina, Bolivia, and Chile each have 20 or more globally threatened species.
- Among species occurring in tropical forests, 52% of species in montane tropical forest are threatened, compared with 36% in lowland tropical forest, probably reflecting smaller range sizes of montane species, the lack of effective habitat conservation in many montane regions, higher human population densities in mountainous areas, the widespread incidence of chytridiomycosis, and the increased vulnerability of montane species to the impacts of climate change.
- Brazil, Mexico, and South America have the greatest number of threatened species (2,803), followed by Colombia (1,058), Ecuador (786), and Brazil (773). Threatened species are more common in tropical and montane regions, but are also found in temperate and subantarctic regions.
- The number of species in the Neotropical Realm is not constant, with declines occurring in some areas and increases in others.
- A total of 389 Neotropical amphibians are associated with flowing water (most of which are montane) are threatened.
- Habitat loss, primarily due to expanding croplands, vegetation removal (including logging), urbanization and industrial development, and introduction of non-native species, is the most important threat to Neotropical amphibians.
- A total of 36% of Neotropical amphibians are associated with flowing water (most of which are montane) are threatened.
- Habitat loss, primarily due to expanding croplands, vegetation removal (including logging), urbanization and industrial development, and introduction of non-native species, is the most important threat to Neotropical amphibians.
- A total of 36% of Neotropical amphibians are associated with flowing water (most of which are montane) are threatened.
- Habitat loss, primarily due to expanding croplands, vegetation removal (including logging), urbanization and industrial development, and introduction of non-native species, is the most important threat to Neotropical amphibians.
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Atelopus species, being known from a single stream in the Cordillera de Minda. The first record of the species was in 1993. (Poulsen and Sanjiv)

The harlequin frogs (genus Atelopus) are small, colourful "jewels" distributed in the humid forests and paramos of Central and South America. The genus is the largest in the family Bufonidae, with about 80 described species distributed from Costa Rica south to Bolivia and eastward through the Amazon Basin into the Guianas (Figure 1). Despite intense study in these species, their conservative morphology and variable colouration have often obscured their taxonomy. Many species have highly variable colour patterns, and different species frequently have similar colour patterns. Recent genetic studies reveal both unexpected genetic diversity among populations, but also great variation within a given taxon. More than 30 previously unrecognized species are currently in the process of being described or being related to the species level.

Atelopus species are associated with streams, although many occur part of the year in terrestrial habitats (Litts 1996). They range from sea level to approximately 4,680m elevation, but the majority live in highlands at 1,500-2,000m. Some species, such as A. varius, A. chiquinquiriensis, A. confronteriensis, and the now Extinct A. brevipes and A. vogli, have been characterized as locally absent, with hundreds of animals seen in a few hundred meters, often during annual breeding events (La Marca and Reinacher 1991; Mantilla and La Marca 2004; Pounds and Crump 1998; Ron et al. 2005). Local endemism is common in the genus, making species particularly vulnerable to extinction. At least 26 species are known from one site (see Roberts et al. 2005).

Sadly, these beautiful and once common diurnal amphibians are now vanishing. A recent study based on 113 Atelopus species (i.e., including all undescribed forms and a few just recently named), revealed that 37% of these species have undergone significant declines, and only 10% have what are believed to be stable populations (La Marca et al. 2005). The majority of the declining species have disappeared in the last two decades only, and many, such as Atelopus varius (CR) are feared extinct; at least 30 species have been missing from all known localities for at least eight years. All species restricted to elevations of above 1000m have declined and 75 percent have disappeared. At least three Atelopus species are considered as Extinct according to the IUCN Red List Categories and Criteria, namely Atelopus geenseis and A. longirostris from Ecuador, and A. vogli from Venezuela (Litts et al. 2004). To put things in perspective, less than 4% of the remaining 442 Critically Endangered amphibian species on the IUCN Red List are Atelopus species.

Figure 1. Richness map of species in the genus Atelopus, with dark red colours corresponding to regions of higher richness. Maximum richness equals four species.

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The frogs of the genera Telmatobius and Batrachophrynus constitute a remarkable group of anurans that occur from central Ecuador in the north, to northern Chile and Argentina in the south (Figure 1). The most recent classification of Telmatobius (Lavilla 2003) includes 56 species, with Peru harboring the highest diversity (22 species), followed by Bolivia (19 species), Argentina (14 species), Chile (10 species); the description of an additional species was in press at the time writing this report (Telmatobius 3 species). Batrachophrynus includes two species (endemic to central Peru), and while we treat it as distinct in the current essay, recent studies have indicated that Batrachophrynus is not a valid genus and should rather be included in Telmatobius (Aguilera and Pacheco 2006; Cordero and Descalzuelas 2005; Sinsch et al. 2005). The genus Telmatobius is mostly aquatic, occupying a wide, albeit montane, altitudinal range (1,300-5,000m asl), and inhabiting habitats as diverse as cloud forests to human-populated and dry pampas. Many species have co-existed with humans for centuries, and, undoubtedly, habitat destruction, mining, agricultural practices and livestock (especially camelids) have been affected by over-fishing and other problems. Although some protection measures have been implemented (such as captive breeding), they have proved to be mostly unsatisfactory (Perez 2005).

Since Telmatobius and Batrachophrynus frogs inhabit montane areas and are stream- or lake-dwellers, their biology and ecology render them particularly susceptible to chytrid infection. Indeed, there is growing evidence that chytridiomycosis is having a direct impact on populations of these frogs. Reports of serious population declines in Telmatobius first came from Ecuador in the 1980s and 1990s (Descailleaux 2005; Sinsch and Auffenberg 2006), and sympatric, i.e. identical or similar, species have been affected by over-fishing and other problems. Although some protection measures have been implemented (such as captive breeding), they have proved to be mostly unsatisfactory (Perez 2005).

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ESSAY 9.3. NEOTROPICAL SALAMANDERS

Living salamanders comprise about 1500 species, representing approximately one-sixth of all amphibians. The order Caudata hosts the largest group of amphibians, the Chinese Giant Salamander (Andrias davidianus, Ch), in which adults measure 180cm from nose to tip of tail (see Essay 4.7) as well as one of the smallest families of several genera of salamanders that achieve sexual maturity at about 35cm in length. Although the number of salamander species is small compared with that of frogs, the diversity of species and life histories, coupled with late 20th century declines and disappearances worldwide, make salamanders an important model for understanding the causes of global change (i.e., climate change, pollution, habitat loss, etc.) and their effect on biodiversity.

Salamanders are more commonly represented in the northern temperate regions of the world. This group has colonized tropical regions like the Sudomandarin in southern Asia and the Madagascar in tropical America. The ctenidium and extent of these tropical populations differ greatly. While tropical American salamanders have been collected by only a few species, the Neotropics have been the stage for a large-scale radiation encompassing almost 45% of all salamander species. The main Neotropical salamander radiation is restricted to a single clade, the supergenus Bolitoglossa (Parra-Olea et al. 2004), which is represented by more than 370 species. The global Amphibian Assessment records 794 amphibian species in Brazil. The rapid discovery and description of new salamander species, including large areas in the Cerrado and Amazon, has been mainly due to fieldwork, have shown that salamanders in the tropics often exhibit a pattern of low diversity, high endemism, and endemism. The Global Amphibian Assessment records 751 native species, of which around 65% are endemic. However, the rate of description of new species in the tropics has been extremely low, and about 7% of its original native forest cover remains intact, and it is regarded as a recognized global biodiversity hotspot (Mittermeier et al. 2004).

In a recent review of amphibian declines in Brazil, Eterovick et al. (2006) found that only 5% of species are affected by the introduction of exotic species; 20% are affected by pollution, and 9% are affected by over-exploitation. The main causes for declines in amphibians in Brazil is undoubtedly habitat destruction, largely as a result of deforestation, agricultural expansion, and infrastructure development and urbanization. However, other factors, such as severe winters, pollution, and acid rain, have also been implicated in amphibian extinctions.
The amphibian fauna of Colombia is among the largest and most diverse on the planet. According to the results of the Global Amphibian Assessment, nearly 700 recognized species of amphibians are known from, or expected to occur in, Colombia, and our current estimate stands at 752. The diversity of amphibians in Colombia is to, to a certain degree, the fortuitous consequence of human politics – it is as if Colombia’s borders were drawn with the specific intent of maximizing its amphibian diversity. That is, Colombia’s amphibian diversity is a function not only of the area of this tropical country, but also its specific location. For example, although two adjacent mountains may share identical climatic conditions, the limited geographic distribution of most Colombian amphibians makes them extremely susceptible to habitat alteration and destruction. This poses a special challenge for Colombian policy makers because humans have caused by the chytrid fungus Batrachochytrium dendrobatidis, caused by the chytrid fungus Batrachochytrium dendrobatidis, caused by the chytrid fungus Batrachochytrium dendrobatidis, caused by the chytrid fungus Batrachochytrium dendrobatidis, caused by the chytrid fungus Batrachochytrium dendrobatidis, caused by the chytrid fungus Batrachochytrium dendrobatidis. Nevertheless, although Colombia’s regional span contributes greatly to the diversity of amphibians, it is the Andean backbone that is most significant (Lynch et al. 1997). Whereas the Lensh and north-east the Andes form comparatively simple systems, in Colombia they divide into three isolated ranges that radiate from the Nudo de Pasto, and these ranges harbor about two-thirds of Colombian amphibians. Among the Andean species, most occur in the cool, moist cloud forests between 1,200 and 2,500m asl, and many are confined to extremely small areas. Although experimental data are lacking, it is assumed that this isolation is due to the adaptation of species to specific environments and their inability to survive under even mildly different conditions. For example, although two adjacent mountains may share identical environmental conditions, the different environments (e.g., higher temperature and lower precipitation) of the intervening valley would serve as a barrier to dispersion and gene flow (Lynch and Duellman 1997). The limited geographic distribution of most Colombian amphibians makes them extremely susceptible to habitat alteration and destruction. 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Threatened Amphibians of the World

The West Indies is a complex assemblage of islands and countries located between North and South America. It is a land of diverse habitats and wildlife species, which makes it an area of high biodiversity. However, many of these species are threatened due to habitat loss, deforestation, and other human activities. The United Nations Environment Programme has identified several priority areas in the West Indies for conservation efforts. These areas include the Greater Antilles, the Lesser Antilles, and the Cayman Islands. Each of these regions has unique biodiversity, with species such as the Eleutherodactylus, Leptodactylus, and Smilisca. The Eleutherodactylus species are particularly threatened due to habitat loss and fragmentation, while the Leptodactylus species are threatened by habitat alteration and climate change. The Smilisca species are threatened by habitat loss and habitat fragmentation. Conservation efforts are needed to protect these species and their habitats. Conservation strategies include the establishment of protected areas, habitat restoration, and community-based conservation programs. Additionally, research is needed to better understand the threats facing these species and develop effective conservation strategies.
In 2005-2006, the world watched as avian flu spread across Asia and into Europe. As we write this, Americans are expecting the disease to cross the Atlantic and infect birds in the United States. Fortunately, at least in the case of bird flu, we have an example of a global monitoring system that can track the spread of disease across geopolitical boundaries, as well as a network of health-care providers that are prepared to treat patients infected by the virus. Although many people will be schooled, many will still suffer from this emerging infectious disease despite the benefit of advanced warning systems, treatment facilities, and trained personnel. But let us consider a different hypothetical situation. What would happen if:

- Entire populations of humans were dying from an unknown disease in remote regions of the world?
- Few scientists or doctors were aware of the situation?
- Nobody contacted the news media or policy makers?
- We realized that this was an epidemic, but we had no monitoring network or treatment system?
- The few personnel trained to detect and potentially treat the disease were distantly located and had neither financial resources nor sufficient infrastructure to offer any help?
- We could prevent deaths in hospitals, but nowhere else?

Where and how could we even begin to offer help? With few data, no dedicated sources of funding, and no infrastructure, the situation would seem impossible. Yet, do to nothing would clearly be unacceptable. In all respects, this is the situation for Latin American amphibians, as population after population succumbs to the frog-killing fungal disease, chytridiomycosis. The current crisis of global amphibian extinctions is the result of multiple causal factors (Ellis and Storfer 2003), but none is more troubling than chytridiomycosis. Considered an emerging infectious disease (Daszak et al. 2000), caused by a recently discovered fungal pathogen, Batrachochytrium dendrobatidis (Bd), chytridiomycosis has been found infecting more than 75% of amphibians and almost all species affected to some degree. Nocturnal surveys prior to October 2004 often produced as many as 170 amphibians, representing as many as 23 species, but those same transects now produce no more than five or six frogs, representing only two or three species. Within a remarkably short space of time, the amphibian community of El Cope has been devastated by this disease, and is not anticipated to recover, because populations have been greatly reduced and because Bd persists at this site.

This report was the first definitive link between catastrophic population declines of amphibians and the sudden appearance of Bd at a site. Within six months, amphibian abundance had been reduced by more than 75%, with 50% of species missing and almost all species affected to some degree. As the disease spread across Asia and into Europe, it became clear that a single pathogen was driving a catastrophic die-off of amphibians across the tropics. More than 1,200 species have been identified as hosts of Bd, and it is likely that both the environment and the frog are potential disease reservoirs (Lips et al. 2000). When populations begin to decline, they can be wiped out in a short period of time with little chance of recovery or replenishment from other populations. It is this lethal combination of an exotic pathogenic fungus (with a broad host range) infecting a highly endemic amphibian fauna with small geographic distributions that produces such high levels of species extinction in very short periods of time. In conclusion, we can expect to see many more mass losses of amphibian species from the Neotropics, as this disease continues to expand its ranges. Within a decade, global amphibian extinctions are anticipated to affect a significant proportion of an entire group of vertebrates, and we propose that it is no longer correct to speak of global amphibian declines but, more appropriately, of global amphibian extinctions.

**References**

