

Scaling a global plan into regional strategies for amphibian conservation

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In 2005, the Species Survival Commission (SSC) of the International Union for Conservation of Nature (IUCN) and Conservation International (CI) convened the Amphibian Conservation Summit to design a global plan of action, the Amphibian Conservation Action Plan (ACAP), to address the decline of amphibian populations worldwide. The IUCN SSC Amphibian Specialist Group (ASG) was formed in 2006 to implement the ACAP. The ASG's objectives are to facilitate the development of new policies within national and international arenas, as well as within the private sector, and to actively develop projects, locally and regionally, all aimed at preventing further species extinctions. The ACAP provides an estimate of the budget required for actions needed to address global priorities for conservation. A strategy and budget for priorities ensures that actions align with areas, geographic and thematic, in greatest need. A critical next step towards advancing the ACAP is refining its objectives within the context of national and regional strategies and engagement by national resource management agencies and non-governmental organizations (NGOs) for successful implementation of conservation actions. To this end, the ASG and partners have been facilitating the convening of working groups to develop strategies for advancing policy development to enable implementation of on-the-ground conservation management within specific regions and countries. A review of strategies in development and completed indicates that conservation planning at the scale of nations and regions is an important step toward reconciling some debates on what actions are of highest priority for global amphibian conservation and illustrates how priorities vary geographically. However, successful translation of scientifically based strategic plans into conservation action in the field has not occurred widely, partly due to a lack of follow up in engaging governments and NGOs to incorporate the plans into their directives. Continued pressure on governments and NGOs is needed to use species assessments as the metric for determining the status of the environment, and amphibian conservation plans as one of the roadmaps for how funding should be allocated to maintain and improve the health of natural ecosystems.

INTRODUCTION

Conservation planning translates knowledge of biology, threats and capacity into priorities for action. The need for such planning is especially critical for amphibians, with nearly 2,000 of the more than 6,000 known species being threatened with extinction according to the International Union for Conservation of Nature (IUCN) Red List of Threatened Species™ (ANONYMOUS, 2010). The Amphibian Conservation Action Plan (GASCON et al., 2007) outlined the major actions needed to curtail a global extinction crisis for amphibians and how resources need to be mobilized to implement these actions. However, it falls short of enabling governments and civil society to take action because the priorities are not nationally or regionally specific. We outline the importance of national planning for amphibian conservation and highlight the international efforts underway to translate the global plan for action into local tactics that will facilitate on-the-ground efforts to reduce the risk of further amphibian extinctions. We report on the major conclusions of national and regional strategy workshops and the potential magnification of conservation outcomes that results from extending amphibian conservation planning from the global plan to national levels. We also discuss what have been the limiting factors that have precluded the positive impacts of recently developed amphibian conservation plans into conservation action in the field.

To date, ten workshops to develop national or regional strategies for amphibian conservation planning have been held to bridge the gap between global and national planning (tab. 1). In addition, plans are underway to hold workshops for two additional regions, South Asia and East/Central Africa. The initial planning for workshops in these two regions has already consolidated information from amphibian researchers in the respective areas and is reviewed here. The IUCN Species Survival Commission's (SSC) Amphibian Specialist Group (ASG) and Conservation International (CI) organized a symposium at the 6th World Congress of Herpetology in 2008 to assess the progress to date in developing these plans and to provide those individuals leading these efforts around the globe with an opportunity to share insights on strategy development.

The impetus for organizing national and regional workshops varied although they all shared the need to address the fact that a large proportion of native amphibian species are highly imperiled (tab. 2). In Brazil, a primary concern was to develop a plan of action to contend with the rapid increase in economic development in much of the country. Organizers in Venezuela recognized the need to coordinate research and conservation activities, particularly for species in decline in the mountainous areas of the country. In South Asia, biologists anticipate that national planning efforts will resonate with government agencies capable of directing funding or other support toward amphibian conservation. In Costa Rica, Ecuador, Madagascar and China, amphibian researchers responsible for leading the efforts to develop national plans indicated that in-situ efforts by government were unlikely to begin without a national plan. Such plans are therefore important if conservation is to progress, especially for microendemic amphibian species, many of which are in these countries (e.g., WILME et al., 2006).

We refer to the importance of regional and national strategies interchangeably. However, in some cases planning has been initially more appropriate at the regional, rather than national, level. In Central America, for instance, environmental planning and decisions on major issues are the remit of the Central American Commission for Environment and Development (CCAD), a consortium of seven countries. Regional planning does not overshadow the value of national plans. Instead, it can set an important stage for the development of national plans and contextualize the amphibian decline problem in light of other major environmental issues being considered in the region. Furthermore, regional plans can be important for developing trans-border projects such as disease containment and management of trans-boundary protected areas.

The 2005 Amphibian Conservation Summit and Amphibian Conservation Action Plan (ACAP; GASCON et al., 2007) focused on eleven major themes including Key Biodiversity Areas, Freshwater and Terrestrial Landscapes, Climate Change, Infectious Diseases, Over-harvesting, Environmental Contamination, Captive Programs (including Genome Resource Banking), Reintroductions, Assessments, Systematics and Bioresource Banking (please see the ACAP for definitions of these themes). We reviewed both completed and developing national strategies according to whether or not recommendations were made along these and other themes. Specifically, we noted whether or not recommendations were made under each theme for research, advocacy and education, or implementation of on-the-ground conservation management (tab. 1).

Table 2. – Species richness, percentage of species threatened or extinct, and percentage of species classified as Data Deficient on the IUCN Red List of Threatened Species (2010.4) by country or region. Note that several regions have numerous undescribed species that have not yet been assessed and are therefore not represented here.

Country/region	Total number of native amphibian species, including extinct species	Percentage of species threatened or extinct	Percentage of species classified as data deficient
Brazil	798	15 %	25 %
China	333	28 %	21 %
Costa Rica	186	33 %	9 %
Kenya	98	7 %	8 %
Tanzania	178	28 %	11 %
Uganda	65	9 %	9 %
Democratic Republic of Congo	215	6 %	23 %
Ecuador	467	37 %	15 %
Madagascar	242	26 %	21 %
Mexico	364	58 %	10 %
Guatemala	140	57 %	8 %
Belize	38	16 %	3 %
Honduras	125	47 %	2 %
El Salvador	32	31 %	0 %
Nicaragua	73	14 %	3 %
Costa Rica	186	33 %	9 %
Panama	197	25 %	13 %
New Zealand	4	100 %	0 %
India	252	26 %	35 %
Sri Lanka	105	50 %	2 %
Bangladesh	32	3 %	3 %
Bhutan	7	14 %	14 %
Pakistan	18	0 %	0 %
Nepal	46	7 %	11 %
Southeast Asia	738	18 %	36 %
USA	272	21 %	5 %
Venezuela	311	23 %	28 %

Although there are different emphases among the action plans, four priorities emerged as clear frontrunners for the countries and regions with completed or developing action plans:

- (1) Habitat protection implementation.
- (2) Infectious-disease research.
- (3) Captive breeding as both a research area and as an action item, particularly for species threatened by infectious disease.

- (4) Improved understanding of amphibian species richness, distributions and ecology.

Importantly, the order of these themes, as presented here, does not reflect consensus among the action plans; these four themes were generally presented as top priorities but not necessarily in the same order. Also, all themes were not always identified as priorities, but at least one was a top priority within every action plan to date.

INCREASING RESOLUTION OF PRIORITIES

At local and regional scales, the development of national and regional strategies reconciles some debates that have developed as to what constitutes the major threat to amphibians (POUNDS et al., 2006; LIPS et al., 2008). Effective national and regional planning brings researchers with different expertise to a common table where all findings need to be considered and translated into a text that will direct natural resource managers and policy makers on what actions need to be implemented. Such a process stimulates careful review of how different lines of research pertain to specific geographic areas within countries, and aids in understanding which management actions are achievable given national or regional capacity, something that is not possible at the scale of global planning. The geographically higher resolution of review tends to invoke consensus because, at the national or regional scale, it is clearer what threats need a response most urgently and what further research may be required to resolve how lesser understood threats are affecting amphibian populations.

National and regional planning also permit a more thorough review of what management options already exist, how some options can be adapted for amphibians, and which require development and field testing. Consequently, concerns about the allocation of global conservation resources should diminish as national plans continue developing. Within Mesoamerica, for example, priorities among countries vary. In Panama, the continued spread of the amphibian chytrid, *Batrachochytrium dendrobatidis* (*Bd*), may be threatening species with extinction and ex-situ programs have been highlighted as a priority for species at imminent risk. In Mexico, on the other hand, where those species most vulnerable to *Bd* may already have become extinct, habitat protection for still extant species is a top priority.

Species-based priority setting has been a natural course for national strategy planning to date and this process will continue to reconcile opposing views on what are the most important actions as regional, national and site-based strategies define priorities at increasingly finer scales. We recommend that priority setting for conservation spending should continue to use species as a metric consistent with global assessments.

NEW PRIORITIES FOR ACTION

We reviewed both completed and developing national strategies according to whether or not recommendations were made along the themes utilized in the global ACAP. Specifically, we noted whether or not recommendations were made under each theme for research, advocacy and education, or implementation of on-the-ground conservation management (tab. 1). Most themes emphasized research and advocacy/education, although the recommendations for these actions varied both among themes and countries.

Implementation of management was recommended primarily under the themes of habitat protection and captive programs, although it is important to note that ex-situ recommendations were the most consistent response to the threat of disease. The scarcity of recommendations for implementation of field management and policy-level projects to deal

with several of the threats underscores continuing uncertainty about the extent to which factors such as exploitation and contaminants impact populations, and underscores a lack of existing mechanisms to implement field management for threats such as infectious disease. In the case of infectious disease, recent research suggests possible in-situ population management techniques (e.g., HARRIS et al., 2009; BRIGGS et al., 2010; VREDENBURG et al., 2010). In other cases, such as for climate change, there is also uncertainty about the full suite of countermeasures that are possible in the field, although adaptive management would allow mitigation options to be explored and optimized over time (SHOO et al., 2011).

The review of threats and priority actions by the national and regional working groups that have convened thus far has identified two issues that were not adequately addressed in the ACAP. In eight national and regional working groups, invasive species other than amphibian chytrid fungus (*Bd*) were identified as a key threat to amphibian richness. In seven cases, the American bullfrog, *Lithobates catesbeianus*, was identified as an invasive species that is a key risk factor for introduction and spread of the amphibian chytrid fungus, although the direct threats posed by introduced species through predation and competition were also frequently cited. Implementation of projects or policies to reduce the threat of invasive species establishing was only recommended in Costa Rica and Madagascar, whereas the importance of research and advocacy was highlighted in most countries where the American bullfrog has already become established.

Possible synergies among threats were emphasized by some working groups as a necessary area of further research, something that was not a focus in the development of ACAP, probably because working groups were convened according to themes during the 2005 Amphibian Conservation Summit, and not provided sufficient time and encouragement to review potential interactions. For example, one possible synergy that is being discussed by the Mesoamerican working group, and may be worth exploring elsewhere, is the interaction between agrochemicals and infectious disease, particularly chytridiomycosis (see DAVIDSON, 2004). It is hypothesized that agrochemicals that reach high-elevation forests due to updrafts from lower elevation agricultural areas may reduce resistance to infection by amphibian chytrid fungus and possibly other pathogens. The formation of working groups to develop national strategies would provide an excellent opportunity for stimulating research projects to address complex problems that are best addressed by a collaborative group representing different skills.

ARE NATIONAL AND REGIONAL STRATEGIES IMPACTING AMPHIBIAN CONSERVATION?

Focusing in from global to national planning may be important for several reasons. First, channels for sharing information pertaining to amphibian conservation are not universally well developed, and mechanisms are not in place to export successful models and learn from less successful efforts to avoid duplication and leverage successes. We cannot expect natural resource managers to remain fully engaged with the literature to design and implement conservation actions for this highly imperiled group. Well-defined recommendations that are nationally or regionally specific ensure that government agencies and local NGOs are provi-

ded the information needed to include threatened amphibians in their mandate and direct resources appropriately.

Second, knowledge of species biology and threat status varies tremendously around the globe (STUART et al., 2004). This has consequences for striking an appropriate balance between basic research and implementation of conservation actions across different regions. The development of national strategies alleviates this problem by defining what work is needed at a scale that is appropriate for suggesting how resources should be allocated between research and implementation.

Third, a global plan in the absence of national strategies can lead to an unintended focus on concentrations of threatened species, with international efforts inadvertently neglecting threatened species that occur in parts of the world with lower amphibian species richness, or regions lacking the past investment to accurately determine amphibian conservation status. National strategies can clearly articulate what is at stake if individual species are lost within a region and provide the springboard from which conservation action can be taken. Without such a springboard, global efforts may continue to direct resources to better studied areas.

Finally, decision makers need clear and specific examples of how the global decline of amphibians is an issue of concern within their country. This final point is critical to change policy and to channel resources toward conservation action. National strategies define the scope of the declining amphibian phenomenon in the context of a nation's existing environmental policies and problems. Recommendations can therefore be made in the context of issues that are already familiar and of concern to decision makers, thereby increasing the likelihood that action is taken to address problems that are relevant to amphibian conservation.

However, although the above points may provide sound arguments for why national and regional strategies are important, the question remains: have they had an impact? There are examples that suggest that national strategies are mobilizing important actions. For instance, in Costa Rica where a Country Conservation Assessment workshop for amphibians was held in 2006, the lack of a national research program was recognized as the main problem for implementing appropriate in-situ conservation actions. Following this workshop, many of the participants started to organize expeditions to better understand amphibian faunas in areas with little information. As a result, two species, *Incilius holdridgei* and *Craugastor fleishmanni*, that had previously been declared Extinct and Possibly Extinct, respectively, on the IUCN Red List of Threatened Species, were rediscovered. Amphibian research in Costa Rica is also now passively coordinated through a list server where reports by researchers are accessible to all (<<http://www.cbsgmesoamerica.org/>>). There are similar examples of how national strategy workshops have catalyzed needed field surveys in Brazil and India, and stimulated education and outreach programs in Venezuela and Costa Rica.

Furthermore, a global search took place between August and December 2010 in 21 countries, on five continents, and involved 126 researchers. An outgrowth of the ASG's initiative to facilitate in-country amphibian conservation planning, it represented a pioneering effort to coordinate a large number of explorations for "lost" species. The goal was to establish whether populations have survived increasing pressures such as habitat loss, climate change and disease, and to help scientists better understand what is behind the amphibian crisis. Out of an initial list of 100 "lost" species, only four amphibians were rediscovered during 2010, but searches continue in many countries.

We identified several direct links between national strategy development and implementation of conservation actions beyond surveys on the ground. The ACSAM (*A Conservation Strategy for the Amphibians of Madagascar*) Initiative (ANDREONE et al., 2008) led to habitat protection for the harlequin mantella (*Mantella cowani*) (RABIBISOA et al., 2009) and conservation action and research on the tomato frog (*Dyscophus antongilii*) (TESSA et al., 2008), and on other amphibians of the Ankaratra and Isalo massifs (MERCURIO et al., 2008). In 2010, the ACSAM initiated actions to begin combating the possible introduction of the amphibian chytrid fungus, namely two workshops held in April and October 2010 where government-level discussion began to consider restricting import of potential vectors of amphibian chytrid carrying organisms (e.g., American bullfrog, *Lithobates catesbeianus*). Activities are underway in other countries for which national strategies may be providing an important context and guidance, but it is not clear that these strategies have played a catalytic role.

In New Zealand, the first Native Frog Recovery Plan was published in 1996 and had a five-year time frame (NEWMAN, 1996). During the course of this plan, a major decline in the stronghold population of Archey's frog (*Leiopelma archeyi*) occurred (BELL et al., 2004) and the main focus of conservation management shifted to studying agents of decline. A new recovery plan outlining the essential priorities for *Leiopelma* conservation is currently in press (BISHOP et al., 2010). The main approaches to conservation management of New Zealand frog populations have centered on translocations to predator-free islands, predator control and amphibian diseases (in particular chytridiomycosis). Current infectious disease research is being conducted on most *Leiopelma* species for chytrid transmission and susceptibility of native frogs to chytridiomycosis. Posters and other advocacy material have been produced to alert members of the public about the implications of chytridiomycosis, and a hygiene protocol has been implemented for all people who work in the field with frog populations.

Beyond the government-supported progress in New Zealand, we identified two categories of direct links between national strategy plans and increased funding for amphibian conservation that resulted in the completion of several projects critical to the survival of Threatened species. National plans have been important in securing support from the ASG, CI and other partnering organizations for habitat conservation proposals resulting in new protected areas for amphibians in Madagascar, Brazil, Indonesia, Ecuador, Mexico, and a nearly completed project in Guatemala. In India, government funds were pledged to searches for amphibians that have not been recorded in the field by scientists for 10 or more years. This funding stream opened up during November 2010 meetings organized by Delhi University to develop a strategy for protecting the remaining habitats of the Western Ghats and a simultaneous initiative to launch a nationwide search for "lost" species. The government representatives who attended the meetings pledged financial support.

Aside from these successes, however, a mismatch remains between the scale at which amphibians are declining and the resources that are being provided to reverse the problem. So, what is missing and how could strategies be more effective? No previous reviews of amphibian strategies exist; however, our review indicates that the plans are generally thorough and well received by the herpetological and broader conservation communities, probably because they have usually been designed by a diverse group of individuals with complementary expertise. In the few cases where plans have been brought to the specific attention of government representatives, they have helped garner financial or logistical support and, in the case of

Madagascar, will hopefully play an important role in guiding the development of new regulations.

The primary limitation to the effectiveness of plans appears to be lack of follow-up in communicating the results of strategic planning to governments and other institutions that could translate these science-based plans into action. Where such translation has happened, government representatives participated in meetings. It may not always be feasible for governments to be engaged at the earliest stages of planning, given the often grassroots effort within the herpetological community in designing and publishing strategies. However, the plans do need to be ultimately worked into the mandates of governments and NGOs if they are to be acted upon at the necessary scales. There is, however, good indication that when there is investment in species conservation, the status of species improves (HOFFMANN et al., 2010).

LESSONS LEARNED FROM MOBILIZING NATIONAL AND REGIONAL STRATEGIES

Despite increasing awareness about the plight of amphibians, herpetologists continue to be the primary constituents in a global effort to reverse population declines and prevent extinctions. Although their expertise and continuing observations are vital to the ongoing efforts to conserve amphibians, much additional effort is needed from new stakeholders in amphibian conservation who can mobilize resources and effect policy change. National and regional planning provides a forum for inviting representatives from government resource management agencies, local NGOs, and individuals who may become engaged in national and regional efforts to advance amphibian conservation. Engagement with resource management agencies is, in most cases, critical to achieving any substantive applied conservation management outcomes at a scale that is meaningful to national and regional amphibian biodiversity. This level of engagement may not always be feasible, especially in countries where investment in resource management is minimal. The publication of a national strategy is nevertheless a valuable tool for initiating discussions with new stakeholders and certainly helpful to governments, organizations, and individuals that may already be engaged but need guidance on what priorities to act upon and how.

A consensus among workshop participants worldwide is an urgent need for further resources to put good plans into action. Although amphibian declines have been widely publicized for 20 years (COLLINS & CRUMP, 2009), funds for the research and conservation of these animals remain meager (ROWLEY et al., 2010). Governments and NGOs often allocate substantial funds to conserving charismatic megafauna. Similar funding for the many amphibian species in these same countries would mark a pivotal turning point in what has been a lukewarm response by governments and NGOs to date.

Amphibian conservationists working on national strategy development have an important opportunity within the United Nations Millennium Goals. Individuals within governments that have ratified the Convention on Biological Diversity (CBD) have been appointed to facilitate and extend achievement of Millennium Goals beyond 2010. The number of threatened amphibians, combined with achievable opportunities for averting extinctions (e.g., new protected areas for species with small ranges, ex-situ programs for

species threatened with disease) provides those who are accountable for meeting Millennium Goals with ready opportunities to claim successes. National strategies provide the vehicle to justify and implement specific actions.

A key challenge for those involved in national strategy development is to engage CBD appointees and provide specific research projects or management opportunities for them. Adopting national strategies at the level of national governments will provide officials with a roadmap for large-scale species conservation. Good action plans illustrate specific options for implementation. CBD appointees who act on these recommendations demonstrate a commitment to protecting an especially threatened group.

Implementation of national plans for amphibian conservation will be enhanced if governments are partners in the development, publication, and, most importantly, implementation of action plans. This may be best accomplished by inviting (or pressuring) key representatives from respective resource management agencies to participate in workshops and follow-up activities.

RECOMMENDATIONS

We recommend that organizers of future workshops strive to have continuous communication with government and NGO representatives and include both in the planning effort whenever possible, so that they are engaged participants with a stake in the outcomes of the plans and their implementation. In addition, governments should be given a chance to voice opportunities for how concerned scientists can most effectively advance the implementation of developing strategic plans. Indeed, the question of how a plan is to be implemented should be a focus of all workshops and the plans they generate. Of course, engaging governments and NGOs on the implementation front is easier said than done. The plight of amphibians has been broadcast quite well and so the inaction of most governments and NGOs to date must largely be due to continued reservations about elevating amphibian conservation to an institutional priority or inertia due to financial and other constraints. Including them in meetings, whenever possible, will hopefully open minds to new opportunities for conservation successes and the mechanisms to achieve these at relatively low cost. Promoting internal review of the issues and the benefits of reaching achievable amphibian conservation goals may best rally mobilization of resources from governments and NGOs.

As proponents of amphibian conservation, future workshop organizers should also think strategically about how to leverage amphibian conservation successes into other beneficial environmental outcomes such as preservation of freshwater resources, carbon offset, reduction of erosion and mudslide risks, security of compounds with potential medical or technological application, and preservation of environments with cultural significance. In this way, amphibian conservationists can help governments and NGOs deliver on what they are accountable for in fiscally and logistically manageable units (i.e., amphibian species) compared to conservation of other groups or thematically based efforts, while fostering greater knowledge and capacity in logical processes for achieving robust conservation management outcomes.

LITERATURE CITED

- ANDREONE, F., CARPENTER, A. I., COX, N., DU PREEZ, L., FREEMAN, K., FURRER, S., GARCIA, G., GLAW, F., GLOS, J., KNOX, D., KOEHLER, J., MENDELSON III, J. R., MERCURIO, V., MITTERMEIER, R. A., MOORE, R. D., RABIBISOA, N. H. C., RANDRIAMAHAZO, HERILALA, H., RANDRIANASOLO, RASOAMAMPIONONA RAMINOSOA, N., RAVOAHANGIMALALA RAMILJAONA, O., RAXWORTHY, C. J., VALLAN, D., VENCES, M., VIEITES, D. R. & WELDON, C., 2008. – The challenge of conserving amphibian megadiversity in Madagascar. *PLoS Biol.*, **6**: 943–946.
- ANDREONE, F. & HERILALA, H., (ed.), 2008. – *Sahonagasy Action Plan. Conservation Programs for the Amphibians of Madagascar / Programmes de conservation pour les amphibiens de Madagascar*. Turin, Museo Regionale di Scienze Naturali, Conservation International, IUCN/SSC Amphibian Specialist Group: 1–96.
- ANONYMOUS [IUCN], 2010. – IUCN Red List of Threatened Species Version 2010.4 <<http://www.iucnredlist.org>>. Downloaded on November 2010.
- BELL, B. D., CARVER, S., MITCHELL, N. J. & PLEDGER, S., 2004. – The recent decline of a New Zealand endemic: how and why did populations of Archey's frog *Leiopelma archeyi* crash over 1996–2001. *Biol. Cons.*, **120**: 189–199.
- BISHOP, P. J., DALGLISH, L. A., HAIGH, A. J. M., MARSHALL, L. J. & TOCHER, M. D., 2010. – Native Frog (*Leiopelma* species) Recovery Plan, 2010–2015. *Threatened Species Recovery Plan*, No. **18**, Wellington, Department of Conservation.
- BOLAÑOS, F., ARGUEDAS, R., RODRÍGUEZ, J. E., ZIPPEL, K. & MATAMOROS Y. (ed.), 2007. – *Taller para establecer una estrategia de conservación de los anfibios de Costa Rica*. 28–30 de septiembre, 01 de octubre, 2006. San José, Costa Rica.
- BRIGGS, C. J., KNAP, R. A. & VREDENBURG, V., 2010. – Enzootic and epizootic dynamics of the chytrid fungal pathogen of amphibians. *PNAS*, **107**: 9695–9700.
- COLLINS, J. P. & CRUMP, M. L., 2009. – *Extinction in our times. Global amphibian decline*. Oxford, Oxford University Press: i–xxiii + 1–273.
- DAVIDSON, C., 2004. – Declining downwind: amphibian population declines in California and historic pesticide use. *Ecol. Appl.*, **14**: 1892–1902.
- GASCON, C., COLLINS, J. P., MOORE, R. D., CHURCH, D. R., MCKAY, J. E. & MENDELSON, J., (ed.), 2007. – *Amphibian Conservation Action Plan*. Gland, Cambridge, IUCN/SSC Amphibian Specialist Group, The World Conservation Union (IUCN): 1–64.
- HARRIS, R. N., BRUCKER, R. M., WALKE, J. B., BECKER, M. H., SCHWANTES, C. R., FLAHERTY, D. C., LAM, B. A., WOODHAMS, D. C., BRIGGS, C. J., VREDENBURG, V. T. & MINIOLE, K. P. C., 2009. – Skin microbes on frogs prevent morbidity and mortality caused by a lethal skin fungus. *ISME J.*, **3**: 818–824.
- HOFFMANN, M. et al. (more than 100 co-authors), 2010. – The impact of conservation on the status of the world's vertebrates. *Science*, **330**: 1503–1509.
- LIPS, K. R., DIFFENDORFER, J., MENDELSON, J. R., III & SEARS, M. W., 2008. – Riding the wave: reconciling the roles of disease and climate change in amphibian declines. *PLoS Biol.*, **6**: 441–454.
- MERCURIO, V., APREA, G., CROTTINI, A., MATTIOLI, F., RANDRIANIRINA, J. E., RAZAFINDRABE, T. J. & ANDREONE, F., 2008. – The amphibians of Isalo Massif, southern-central Madagascar: high frog diversity in an apparently hostile dry habitat. In: F. ANDREONE (ed.), *A conservation strategy for the amphibians of Madagascar, Monografie*, **45**, Torino, Museo Regionale di Scienze Naturali: 143–196.
- MOLINA, C., SEÑARIS, J. C., LAMPO, M. & RIAL, A. (ed.), 2009. – *Anfibios de Venezuela. Estado del conocimiento y recomendaciones para su conservación*. Caracas, Venezuela, Ediciones Grupo TEI: 1–130.
- NEWMAN, D., 1996. – Native frog (*Leiopelma* spp.) recovery plan. *Threatened Species Recovery Plan*, No. **18**, Wellington, Department of Conservation: 1–35.
- POUNDS, J. A., BUSTAMANTE, M. R., COLOMA, L. A., CONSUEGRA, J. A., FOGDEN, M. P. L., FOSTER, P. N., LA MARCA, E., MASTERS, K. L., MERINO-VITERI, A., PUSCHENDORF, R., RON, S. R., SÁNCHEZ-AZOFFEIFA, G. A., STILL, C. J. & YOUNG, B. E., 2006. – Widespread amphibian extinctions from epidemic disease driven by global warming. *Nature*, **39**: 161–167.

- RABISOA, N., RANDRIANASOLO, H., ANJERINAINA, M., MACKINNON, J., ANDRIAMAMONJISOA, A., RAMANDIBISON, RANDRIANANTOANDRO C. & ANDREONE, F., 2009. – New findings of harlequin mantella improve the conservation of Madagascar's most threatened frog. *Froglog*, **92**: 5–8.
- ROWLEY, J. L. J., BROWN, R., BAIN, R., KUSRINI, M., INGER, R., STUART, B., WOGAN, G., THY, N., CHAN-ARD, T., TRUNG, C. T., DIEMOS, A., ISKANDAR, D. T., LAU, M., MING, L. T., MAKCHAI, S., TRUONG, N. Q. & PHIMMACHAK, S., 2010. – Impending conservation crisis for Southeast Asian amphibians. *Biol. Lett.*, **6**: 336–338.
- SHOO, L. P., OLSON, D. H., MCMENAMIN, S. K., MURRAY, K. A., SLUYS, M. V., DONNELLY, M. A., STRATFORD, D., TERHIVUO, J., MERINO-VITERI, A., HERBERT, S. M., BISHOP, P. J., CORN, P. S., DOVEY, L., GRIFFITHS, R. A., LOWE, K., MAHONY, M., MCCALLUM, H., SHUKER, J. D., SIMPKINS, C., SKERRATT, L. F., WILLIAMS, S. E. & HERO, J., 2011. – Engineering a future for amphibians under climate change. *J. appl. Ecol.*, **48**: 487–492.
- STUART, S. N., CHANSON, J. S., COX, N. A., YOUNG, B. E., RODRIGUES, A. S. L., FISCHMAN, D. L. & WALLER, R. W., 2004. – Status and trends of amphibian declines and extinctions worldwide. *Science*, **306**: 1783–1786.
- TESSA, G., GUARINO, F. M., GIACOMA, C., MATTIOLI, F. & ANDREONE, F., 2008. – Longevity and body size in three populations of *Dyscophus antongilii* (Microhylidae, Dyscophinae), the tomato frog from north-eastern Madagascar. *Acta herp.*, **2**: 139–146.
- VREDENBURG, V., KNAP, R. A., TUNSTALL, T. S. & BRIGGS, C. J., 2010. – Dynamics of an emerging disease drive large-scale amphibian population extinctions. *PNAS*, **107**: 9689–9694.
- WILME, L., GOODMAN, S. M. & GANZHORN, J. U., 2006. – Biogeographic evolution of Madagascar's microendemic biota. *Science*, **312**: 1063–1065.

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