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News from the herpetological community

Regional Focus Maritime Southeast Asia and Oceania



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Spotted Treefrog *Nyctixalus pictus*. Photo: Leong Tzi Ming



**New
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The 2012 Sabin Award for Amphibian Conservation is now open for nomination

Amphibian Specialist Group



Non-Profit Organization



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Amphibian Specialist Group

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Alison Haskell Award

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Partners in Amphibian and Reptile Conservation

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Craig Hassapakis

AMPHIBIAN AND REPTILE CONSERVATION, found at: www.redlist-ARC.org
Citation: Jansen, P. and Bopage, M. 2011. The herpetofauna of a small and unprotected patch of tropical rainforest in Morningside, Sri Lanka. Amphib. Reptile Conserv. 5(2):1-13(e26).
Download here: [http://file.it/wu14hxt/ARC_5\(2\)_01-13_e26.pdf](http://file.it/wu14hxt/ARC_5(2)_01-13_e26.pdf)
Published: 29 October 2011.



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HerpetoGasy BioBlitz
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SAVE THE FROGS!

13,777 like this



Wildlife Conservation Society

20,261 like this



Conservation Breeding Specialist Group

958 like this

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www.facebook.com/amphibiansdotorg



2012 Amphibian Ark calendars are now available!

The twelve spectacular winning photos from Amphibian Ark's international amphibian photography competition have been included in Amphibian Ark's beautiful 2012 wall calendar. The calendars are now available for sale, and proceeds from sales will go towards saving threatened amphibian species.



Pricing for calendars varies depending on the number of calendars ordered – the more you order, the more you save! Orders of 1-10 calendars are priced at **US\$15 each**; orders of between 11-25 calendars drop the price to US\$12 each; and orders of 26-99 are priced at just US\$10 each. (These prices do not include shipping).

As well as ordering calendars for yourself, friends and family, why not purchase some calendars for re-sale through your retail outlets, or for gifts for staff, sponsors, or for fund-raising events?



Order your calendars from our web site:
www.amphibianark.org/calendar-order-form/

Remember – as well as having a spectacular calendar to keep track of all your important dates, you'll also be directly helping to save amphibians, as all profits will be used to support amphibian conservation projects.



www.amphibianark.org

froglog

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Editorial

I am delighted to be invited to write the editorial for this Maritime Southeast Asia and Oceania edition of FrogLog. The new format of FrogLog has stimulated a renewed interest in amphibian conservation and vote of thanks is due to James Lewis (ASG Program Coordinator) for producing such a professional and informative 'Newsletter'.

The Amphibian Survival Alliance (ASA) is starting to take shape with the appointment of Jaime Garcia Moreno as the Executive Director and myself as the Chief Scientist. The ASA is the umbrella organization formed to oversee the implementation of the Amphibian Conservation Action Plan at a global level. We are working very closely with many other institutions involved in amphibian conservation, such as the Amphibian Ark, and to cement the ties with the Amphibian Specialist Group I have been appointed as the Deputy Chair of the ASG. (For more information on ASA please see [FrogLog 97](#)).

This edition has a regional focus on Maritime Southeast Asia and Oceania and as I am based in New Zealand, I have been fortunate enough to have worked on frogs in New Zealand, Australia, Singapore and Melanesia. This is a very exciting part of the world to explore from an amphibian perspective. The region contains 1047 species of amphibians (1028 anurans and 19 caecilians) of which 24 are Critically Endangered, 53 are Endangered, 102 are Vulnerable and more importantly 285 are Data Deficient (according to AmphibiaWeb 2011 – special thanks to Kellie Whitaker for providing this data). I would like to propose a challenge for all local and visiting herpetologists that by the time its our turn again to report to Froglog on the amphibians of this region that we have significantly reduced the number of data deficient species.

Some of the many highlights in this edition include the renewed interest in Philippine herpetological research, the rediscovery of a population of the highland bell frog (*Litoria castanea*) in Australia, and the discovery that the lungless frog (*Barbourula kalimantanensis*) is not as rare as we previously thought. In New Zealand as all the indigenous frogs seem to be able to cure themselves of chytridiomycosis in the lab, we have recently been focusing on ex situ interventions, introduced pest control and habitat protection. We have downscaled the ACAP to a local plan and this should hopefully be published by the end of the year.

Finally I would like to thank the many contributors to this edition and again to James Lewis for all his hard work in putting these newsletters together.

Phillip J. Bishop
ASG Deputy Chair



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News in Brief

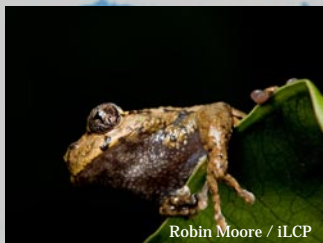
The IUCN SSC Amphibian Specialist Group (ASG) is a global network of dedicated experts who donate their time and expertise to create a community from where practical amphibian conservation can be advanced based on a solid foundation of science. The ASG is directly involved in supporting the activities of a number of amphibian conservation projects around the world. Here you can see a few updates from projects we are currently supporting and other news of interest. More information on ASG supported projects and the work of ASG members and partners around the world can be found on our web site at www.amphibians.org.

Amphibian Sp

Helping to Protect Amph

Guatemala

In Guatemala, the ASG is helping local NGOs to purchase and protect two areas of land important for amphibian conservation. The Motagua Valley consists of 58 Hectares of dry forest to save it from being mined, safeguarding a newly discovered species of salamander that is restricted to this area. The Sierra Caral project is leading to the protection of 2,200 hectares of one of the largest tracts of intact primary cloud forest remaining in Central America. If you are interested in helping support these efforts visit our web site to find out more <http://www.amphibians.org/our-work/projects/guatemala/>.



Robin Moore / iLCP

South America

The 100th edition of FrogLog will be out mid January 2012. The first edition of FrogLog came out in March 1992 and we are still going strong. If you have any stories of FrogLogs past that you like to share please drop us a line. The regional focus of the January edition will be South America. If you would like to publicize your amphibian conservation efforts please contact the appropriate regional chair or James Lewis at jplewis@amphibians.org.



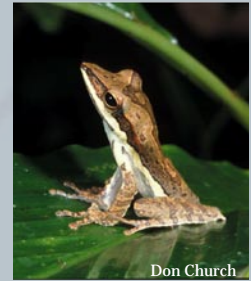
Robin Moore / iLCP

Specialist Group

Amphibians Around the World

Sri Lanka

The ASG is actively supporting the development of an amphibian habitat monitoring and habitat restoration program in Morningside, Sri Lanka through a grant part funded by the Save Our Species program. Read more about this incredible region that is currently under threat and the importance of the program in the next edition of FrogLog.



Don Church

Sulawesi

The ASG is supporting local partner the Alliance for Tompotika Conservation, or "AlTo" to establish a new protected area in the heart of Mt. Tompotika, an area that is both one of the most biologically valuable and most immediately threatened areas in the region. Read more about this project on page 8.



Robin Moore / iLCP

New Zealand

The ASG is pleased to announce that Phillip J. Bishop (ASG Regional Chair for New Zealand) will be taking on a new role as the Deputy Chair of the ASG. Phil is also the Chief Scientist of the Amphibian Survival Alliance and having a role within both groups will help to forge our future partnership.



Also, with the help of New Zealand's ASG members and others, New Zealand has become one of the first countries to record all of their amphibian species on the Global Amphibian BioBlitz (GAB). Well done New Zealand, we wonder who will be next? Read more about this and other GAB news on page. 15

Mount Tompotika

Mount Tompotika is a 1,600m forested mountain on the extreme eastern tip of Central Sulawesi, Indonesia. Considered a sacred place of origin for all three of the ethnic groups indigenous to the area, the mountain forms the center and focal point of the Tompotika peninsula. Until recently the mountain was completely uninhabited and shrouded by mystery.

Text and Photos By Robin D. Moore iLCP



*A beautiful Sulawesi toad, *Ingerophrynus celebensis*, a species endemic to the island of Sulawesi sits on a rock in a stream that weaves its way through lush primary rainforest on Mt Tompotika*



A frog endemic to Sulawesi, *Hylarana mocquardii*, found during our night-time searches along a stream in the new Protected Area.

system of patrolling and restoration work. A pool of villagers is being trained in forest patrolling, planting, and management techniques, rotating these responsibilities to ensure a constant presence. AITo staff will perform the necessary, ongoing forest management tasks of patrolling for logging/poaching; restoration planting; and general forest stewardship. In this way, the core forest area, which is under threat, will be protected while the degraded forest of the buffer zone will be restored, promoting local pride and serving as a model for restoration of other degraded forest areas and the protection of key amphibian habitat in Sulawesi and beyond.

We wish to thank Andrew Sabin and the Sabin Family Foundation, George Meyer and Maria Semple, and the Save Our Species Fund for supporting this project.

How little we know about the fauna of the island was highlighted during surveys in recent years that found the presence of two new frog species – one *Limnonectes* sp. and a *Polypedates* sp. These join *Ingerophrynus celebensis*, *Rana celebensis*, *Hylarana mocquardii*, *Limnonectes modestus* and *Occidozyga semipalmata* in making Mount Tompotika an important area for amphibians.

Some of the prime habitat on Tompotika has recently been put in jeopardy, however, as forests are being logged, roads have been built and new villages established in its foothills. Add to this the new threat of nickel mining and Mt Tompotika's unparalleled biodiversity - that in addition to amphibians includes marsupials, primates, hornbills, psittacines and Draco lizards - look precarious. In response to the increasing threats and owing to the uniqueness of the forest habitat on Tompotika, the ASG teamed up with local NGO the Alliance for Tompotika Conservation (AITo) to develop plans for a new protected area in the heart of Mt Tompotika, an area that is both the most biologically valuable but also the most threatened in the region.

Originally aiming for a preserve encompassing 1,000 hectares of intact primary forest, the partners were stunned when negotiations led to ten times this amount being set aside through an agreement between AITo and villagers. The 10,000 hectare area will enjoy strict protection under this agreement from logging, hunting, mining and other anthropogenic threats. It will also, in effect, serve to protect the mountain's flanks on both sides and above it, since this area is currently the main gateway for local people to access the rest of the mountain. The project employs a team of local community members to manage, preserve, and improve the forest of Mt Tompotika through a



Our guide looks happy after catching a giant *Limnonectes* frog from a stream that is now protected on Mount Tompotika

Taking the pulse of the planet's biodiversity: a new tool for tracking changes in amphibian abundance



By Ben Collen, Jonathan Loh, Phil Bishop, Jaime Garcia-Moreno, Robin Moore & James Lewis

By gathering together information and expertise from networks of scientists, such as the IUCN SSC Amphibian Specialist Group, it is possible to make great inroads into understanding biological patterns and extinction process, as proven by the Red List. Measuring conservation status nevertheless only tells part of the story. However we choose to measure it, biodiversity has changed more rapidly in the past 50 years than any other period in human history (Millennium Ecosystem Assessment 2005). The human drivers of biological change - habitat degradation, over-exploitation, pollution, invasive species and increasingly a changing climate - show little sign of abatement on a broad scale. These forces have led to many thousands of species, including one third of amphibians, being listed as threatened with extinction (Stuart et al. 2008; Stuart et al. 2004). Without removing or reducing these causes of biodiversity loss, we will only watch the symptoms of their impact get worse.

A wide range of indicators are now being used to track the state of biodiversity, the pressures upon it, and the steps being taken to address those trends (Butchart et al. 2010; Convention on Biological Diversity 2010). These measures are critical to understanding the nature of changing in biodiversity and to

enable proactive intervention. One of the longest-running measures of the trends in the state of global biodiversity, the Living Planet Index (LPI: Collen et al. 2009; Loh et al. 2010; Loh et al. 2005), shows a consistent overall trend: a global decline of almost 30 per cent between 1970 and 2007 (Figure 1). This index tracks the fate of around 9,000 populations of over 2,650 species of vertebrates, in much the same way as a stock market index tracks the price of a basket of shares. The decline in the LPI over the period 1970-2007 equates to a 30 per cent decline in population size on average. The same period showed close to a doubling of the human population. Amphibians, freshwater fish and large mammals are in particularly serious decline. Losses were most severe in tropical countries, where wildlife populations that are monitored underwent an average 60% decline in abundance in little less than 40 years, principally due to changing land use, habitat destruction and the effects of over-hunting and over-fishing. These dramatic figures of change in population are reflected in many other measures of biodiversity change including remaining forest area, species conservation status and coral reef condition.

Using aggregated indicators of population change is a widely applied technique for tracking the fate of groups of species, and has been useful in diagnosing changing trends in species groups such as birds (Gregory et al. 2005), and butterflies (Van Dyck et al. 2009), and in a variety of biomes from the Arctic (McRae et al. 2010) to Mediterranean wetlands (Galewski et al. 2011). Ultimately, population-trend data provide a complement to the longer-term, but more coarse-grained, perspectives gained by evaluating species-level extinction risk. Combined, they may offer a robust and broad view of the changing state of nature.

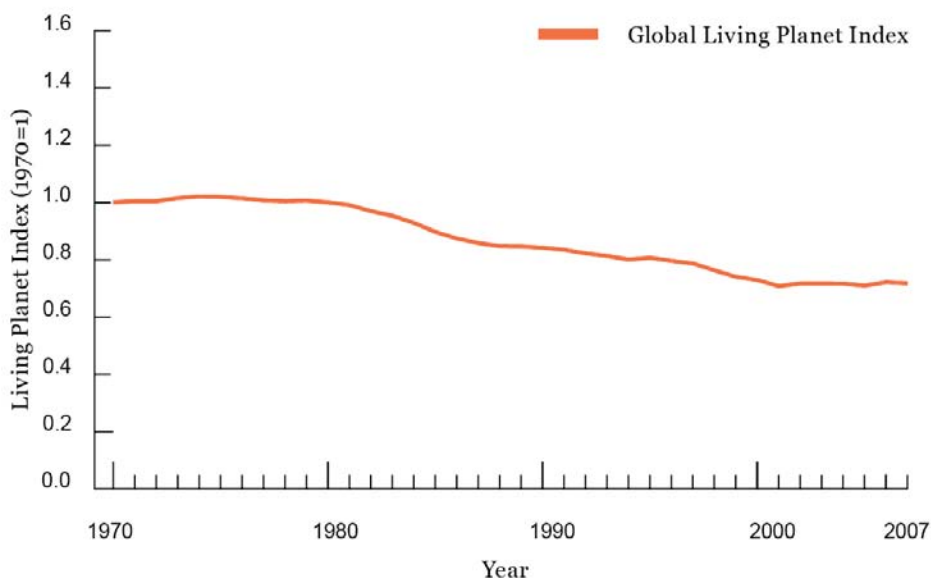


Figure 1. Living Planet Index - The global index shows that vertebrate species populations declined by almost 30 per cent between 1970 and 2007 (ZSL/WWF, 2010)

The Amphibian Survival Alliance (ASA), in collaboration with the Zoological Society of London and WWF, aims to develop a new index of amphibian population change. WWF and ZSL have made an amphibian LPI in the past, and the result shows a more rapid decline than that of any other vertebrate group. But we don't know if the existing data on population trends are truly

representative of all amphibian species around the world, or if the nose-diving index is a reflection of the effort that has been put into monitoring amphibians that were already known to be in decline. We are therefore making a major effort to gather as much population time series data on amphibian species. Data on any species, from any parts of the world, are valuable, but especially species from Africa or Asia, where the current dataset is thinnest. If you are currently monitoring amphibian populations or can help us to find potential data sources, we should be particularly grateful if you could contact Jaime Garcia Moreno or Phil Bishop at ASA at your earliest convenience.

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The Living Planet Index

The Living Planet Index (LPI) is a measure of the state of the world's biological diversity based on population trends of vertebrate species from around the world. The Amphibian Survival Alliance (ASA), in collaboration with the Zoological Society of London and WWF, aims to develop a new index of amphibian population change. To find out more about the LPI download the fact sheet here static.zsl.org/files/1-2-1-living-planet-index-1062.pdf or contact Jaime Garcia Moreno (jaime.garciamoreno@iucn.org) or Phil Bishop (phil.bishop@iucn.org) to find out how you can get involved in this innovative initiative.

Members' Bulletin Board

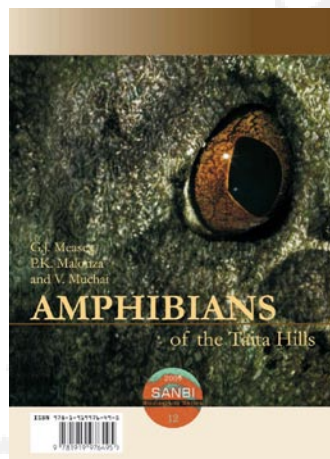
ASG + LinkedIn = Better Networking

We are pleased to announce yet another communication tool being added to our ever increasing communication tool bag here at the ASG, a LinkedIn group. LinkedIn is the world's largest professional online networking community. It allows you to connect to your trusted contacts and helps us all exchange knowledge, ideas, and opportunities with a broader network of professionals and interested parties. As the ASG is a network of experts our strength and effectiveness will come from our ability to communicate effectively as a group. It is clear that no single method of communication will suit such a diverse group so we are continuing to develop a range of tools to meet our member's needs and the needs of the greater amphibian conservation community. We hope that all of our members take the time to join this group and help build these important connections and develop the effectiveness of the ASG. To join the ASG LinkedIn group please go to <http://www.linkedin.com/groups/IUCN-SSC-Amphibian-Specialist-Group-4014628>

Call for regional calendar volunteers

Last month the ASG launched its new web site (read more about this in FrogLog vol. 98). As part of the web site we have included an events calendar that we are hoping to fill with amphibian related events from around the world. Each Regional ASG Chair has access to this google calendar in order to include regional events; however, we are looking for six or more volunteers to assist in keeping the calendar up to date. Ideally we are looking to have at least one volunteer for each of the broad ASG geographical zones, so if you are able to offer your time to help with this important role, or would like more information, please contact James Lewis at jplewis@amphibians.org.

Recent Publications added to the web site



Red List Amphibian Assessment Forum

Since the release of FrogLog vol. 98, the ASG has launched its new web site. Within this web site is the new amphibian online assessment forum, a collaboration between the IUCN SSC Amphibian Red List Authority (Amphibian RLA) and the Global Amphibian BioBlitz (GAB). This is an effort to address amphibian reassessments and engage with a wider spectrum of experts in the assessment process. Currently, a selection of draft assessments from a recent workshop in the Dominican Republic are open for feedback, and other assessments will continue to be added to the forum as they reach the assessment consultation process. Assessments will be available for feedback for a specified period of time, after which feedback will be considered/incorporated and the updated assessment will be sent out for external review. The distribution maps in these assessments show either new modified draft range maps or previously published maps (where there are no changes to distribution) alongside contributions from the GAB. The currently posted Hispaniolan and Jamaican assessments will remain online for comments for another month at least.



The ASG library (<http://www.amphibians.org/asn/publications/>) continues to grow with the addition of two fantastic publications for Africa. We thank John Measey for bringing these two publications to our attention and hope that our members find them of interest.

Amphibians of the Taita Hills – A detailed field guide to the amphibians of the Taita Hills with photographs, distribution maps and detailed descriptions of each species.

Ensuring a Future for South Africa's Frogs - This document prioritizes research on threatened species in South Africa. Chapters include a general introduction on global and local amphibian decline, research priorities for taxonomy, conservation, monitoring and public awareness.

If you have any publications that you feel should be included on the ASG web site please contact James Lewis at jplewis@amphibians.org. We are particularly interested in collating all amphibian action plans and encourage all regional groups who have produced such a document to contact us with details.

The Sabin Award for Amphibian Conservation

*T*hanks to a generous donation from Andrew Sabin, the IUCN SSC Amphibian Specialist Group (ASG) announces the fifth annual award to recognize individuals who have made a significant contribution to promoting the conservation of globally threatened amphibians. The award of US\$25,000 is open to individuals from all disciplines relevant to amphibian conservation and research anywhere in the world. Nominations of individuals from developing countries are highly encouraged.

Nomination forms and supporting information can be found on the ASG web site at <http://www.amphibians.org/asg/grants/>. The closing date for nominations is the 29th January 2012.





The Herpetologists' League

EE Williams Research Grant

The Herpetologists' League is pleased to announce competitive grants for graduate student research for 2012. These awards are named in honor of the late Ernest E. Williams, the first Distinguished Herpetologist of The Herpetologists' League.

Overview

1. An award (\$1000.00 maximum amount) will be presented to one winner in each category:

Behavior

Conservation

Ecology

Physiology

Morphology/Systematics

2. See HL web site for application form, complete rules and details: <http://www.herpetologistsleague.org/dox/eewilliamsgrant.pdf>.

3. Entries must be received by 5 PM Mountain Time on 15 December 2011.

4. Send complete application (cover page, proposal, budget, CV,) as a single PDF electronically to: Erin Muths at muthse@usgs.gov. Please put "EE Williams Research Grant" in subject line.

5. One letter of support should be sent, preferably by e-mail, directly by the supporter.

6. Proposals will be reviewed by at least two professional scientists, who will provide written feedback by April 2012.

7. Funding dispersed in April 2012 and winners announced at the Herpetologists' League Business Meeting in Vancouver, British Columbia, 2012.

Rules – please read, the rules have changed from last year

1. The applicant must be a member in good standing of The Herpetologists' League.

2. The applicant must be registered and in good standing in a degree-granting program (MS and PhD candidates eligible).

3. One proposal per applicant per year.

4. Project must be original work, authored and conducted by the applicant.

5. Projects that are already fully supported by other sources are not eligible.

6. The proposal category must be clearly designated. However, HL reserves the right to judge proposals under a category different from that requested based on evaluation of the subject matter and the number of proposals received in each category.

7. Previous winners are NOT eligible for the award in subsequent years.

8. A short report (2 pg) summarizing the results of the project and a reprint or .pdf of any publication arising from the project is due to secretary of HL when available.



Photo: David Herasimtschuk.

Preparation Guidelines (see website for more details)

1. Word limit: 1200 words not including citations, budget, cover page or CV.

2. Double spaced, 12 pt font.

3. Margins: 1 inch.

4. Include the cover page provided at the HL website.

5. Include a detailed budget, as well as sources and amounts of current and pending support.

6. Clearly designate the proposal category on the cover page.

7. Arrange in advance for one letter of support to be sent separately by the supporter.

8. Include a two-page CV that includes telephone, e-mail, and mailing addresses.

A Regional Approach to the Global Amphibian BioBlitz



By Scott R. Loarie & James P. Lewis

The Earth's nearly 7000 species of amphibians are not evenly distributed across the globe. There are more in those countries that are large and have suitable climates (Figure A). The **Global Amphibian BioBlitz**, a citizen-science effort powered by **iNaturalist.org**, has to-date logged about 14% (943 species) of the world's amphibians in just over 6 months, an encouraging start to an initiative aiming to digitally record every known species of amphibian. These numbers represent the combined efforts of over 300 contributors who have logged nearly 3000 observations from 78 countries.

About 29 of the 207 countries with amphibians have had all of their amphibian species reported in the BioBlitz somewhere in the world, and 91 countries have had at least 50% of their amphibians check-in. These countries with complete or nearly-complete lists tend to have modest numbers of endemic species (Figure B). The United States, Madagascar and several Neotropical countries are noteworthy exceptions mentioned below. You can find more country level statistics [here](#).

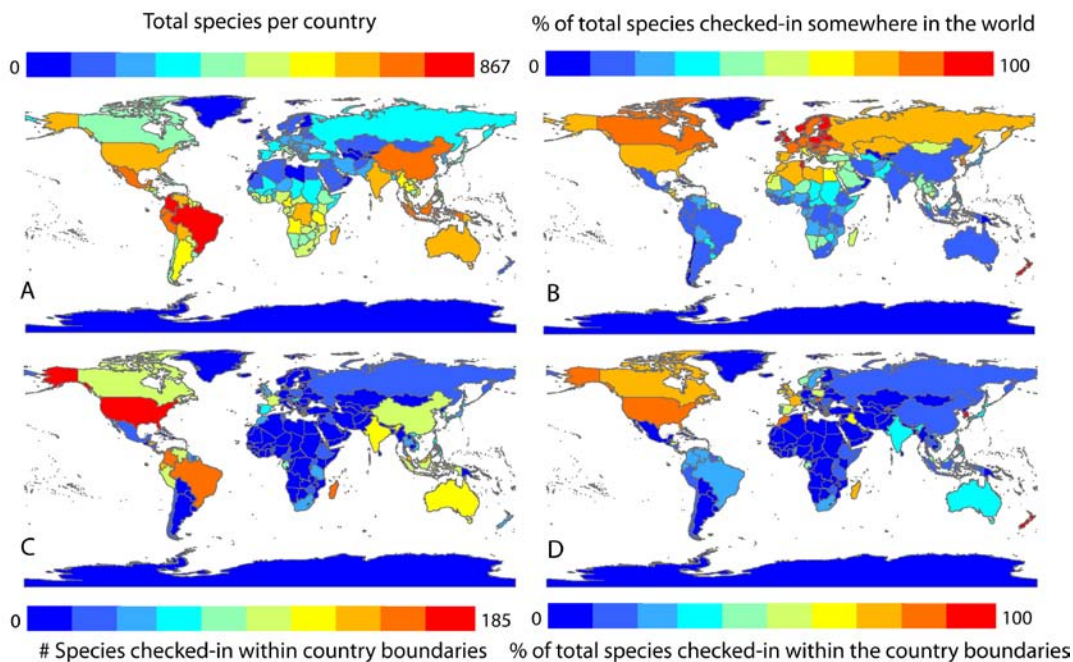
If we are interested in comparing activity across countries, perhaps a more useful statistic would be the number of amphibian species that have checked-in within the boundaries of that country (in-house, as it were). Upon mapping this statistic, the high activity in the United States, the Neotropics, and Madagascar relative to Europe and mainland Africa is immediately apparent (Figure C). As a percentage of total species, only New Zealand has checked-in all 7 of its species in-house. A dozen countries/dependencies have completed at least half of their in-house lists (Figure D). Alongside New Zealand, they are: South Korea (17/18), Hong Kong (22/28), Hungary (13/17), Netherlands (11/16), Morocco (7/11), United States (185/295), Jersey (3/5),

France (22/40), Reunion (1/2), Tunisia (3/6), United Kingdom (7/14). Here, the numerators represent the number of species that have checked in and the denominators represent the total number of species reported for the country/dependency.

While we continue to solicit observations from as many contributors as are willing, we've taken steps to encourage observations to become 'research-grade', so as to increase the utility of these data for science. To become research-grade, each observation must be dated, accompanied by a photograph, geo-referenced, and have its identification corroborated. The primary challenge for contributions to the BioBlitz achieving research-grade status is receiving community support for the species identification. For example, while over 90% of BioBlitz contributions have photographs, only about a third have had their identification corroborated by someone else. For comparison, only 90 of 295 species on the United States country-list have been confirmed with research-grade observations. Under this stricter research-grade criterion, only New Zealand, Morocco, Jersey, and the Netherlands have completed at least half of their respective country lists.

As it happens, facilitating the completion of country lists in-house and encouraging research-grade observations can both be achieved by regionalizing the BioBlitz at the country scale. This is evidenced by Madagascar and Colombia, where regional projects on iNaturalist linked to the Global Amphibian BioBlitz have been begun. They are the **HerpetoGasy BioBlitz** by Sahonagasy.org in Madagascar and **Amphibians and Reptiles of Colombia** by **ACHerpetologia**. Combining regional focus and expertise, these projects have resulted in high percentages of species confirmed with research-grade observations despite the fact that

they involve two of the richest amphibian faunas on the globe. To encourage such regional focus, we've released a new set of country-level amphibian species guides. To view these guides please go to <http://www.inaturalist.org/places> and click on your country of interest. By browsing each guide you can quickly see how many amphibians have checked-in with research grade observations and by whom. If you are familiar with any of the species marked with yellow flags, click on them to help confirm observations. We're excited about the potential of exploring this regional focus in helping the BioBlitz meet its goals and look forward to your participation and feedback.



Regional Updates

Maritime Southeast Asia and Oceania

Each edition of FrogLog focuses on one of the six geographical areas as outlined in [FrogLog 96](#) (pg 6-7). This format provides regional ASG's with an opportunity to showcase their conservation efforts and publicize issues of concern. In this edition we focus on Maritime Southeast Asia and Oceania, a zone consisting of seven ASG regional groups.

Australia

Australia was one of the first countries to recognize that amphibian declines (frog declines since we have no other native amphibian groups) are a serious problem. Work on the first national Action Plan commenced in the mid-1990s, and a national workshop was held in 1997, leading to the publication of the book *Declines and Disappearances of Australian Frogs* (Campbell 1999), a compendium of papers by Australian frog researchers that is still available as a downloadable pdf, and contains a great deal of useful background on Australian frog declines. Regional and taxon-specific recovery teams were formed and plans were written, but many were slow to reach full acceptance, and because the underlying causes of declines were poorly known, many plans consisted largely of research rather than recovery actions. The discovery of the amphibian chytrid fungus in Australian and other amphibians, first reported in by Berger et al. (1998), provided a potential mechanism for mortality in many declines, and a conference held in Cairns, Australia in 2000 was the first international meeting to explore the role of disease in declines; a workshop held after this conference led to the eventual development of the Australian threat abatement plan (Department of the Environment and Heritage 2006). Australia was also one of the first countries to complete an initial assessment of its entire amphibian fauna. A more complete summary of this history, with information on how it fits into the global response to the problem, is available in a recent review chapter (Alford 2010).

Relatively soon after the discovery of the amphibian chytrid fungus, it became evident that it was widespread in continental Australia (Department of the Environment and Heritage 2006). Herpetologists in all major centers have worked on declines, including work on chytridiomycosis, and research on frog biodiversity and conservation in Australia continues to accelerate. Much work through 2009 is discussed in Alford (2010), which, because of the rapid pace of research, is already well out of date. Southeastern Australia is a particular hotbed of research. Much current work is documented in the separate articles in the current FrogLog by Frank Lemckert, Chris Banks, Deborah Bower, and Aimee

Silla. In addition, research coordinated by the Tasmanian Department of Primary Industries, Parks, Water and Environment continues on documenting the distribution of the amphibian chytrid fungus in Tasmania and testing the hypothesis that its spread may have been assisted by the transport of water for roadworks. Work in the west is also proceeding on multiple fronts; Paul Doughty at the Western Australian Museum is continuing to work with the fauna of the northwest and Kimberly regions, and Dale Roberts and his students at the University of Western Australia have been carrying out work in the highly seasonal habitats of the southwest. Many other active research groups are looking throughout most of the continent both at the impacts and status of chytridiomycosis and at other factors affecting or likely to affect the diversity of Australian frogs.

The northeastern region, which suffered particularly heavily in the initial wave of chytridiomycosis-associated declines (Alford 2010) is also the focus of much research and many researchers. Recently, Conrad Hoskin, now of James Cook University, described two new species of microhylids from Cape York Peninsula (Hoskin and Aland 2011), and Robert Puschendorf and colleagues reported on the discovery of a previously unknown population of a species, the Mountain Mistfrog *Litoria lorica* that had not been seen for 17 years (Puschendorf et al. 2011). This population is located in habitat outside the known geographical and environmental range of the species, and the authors suggested that such peripheral populations may be very important for conservation when populations in a species core range are affected by factors like emerging epidemic diseases, as they may experience environmental conditions that reduce the severity of effects on populations (Daskin et al. 2011). Other researchers in the branch of the JCU Amphibian Disease Ecology Group (ADEG) centered in the School of Marine and Tropical Biology have amassed large data sets on environmentally-mediated disease dynamics and how these affect survival in numerous rainforest frog populations. The same group is working on interactions between the skin microbiota of frogs and the amphibian chytrid fungus, and has found that many frogs harbor bacteria that produce anti- anti-chytrid metabolites,

and that the production of these substances is affected by bacterial density via quorum sensing and by responses to environmental temperature. Numerous publications and theses are in late stages of preparation. Researchers in the JCU ADEG affiliated with the School of Public Health and Tropical Medicine at JCU, including Lee Berger, are also pursuing work on understanding the chytrid and how frogs respond to it, as well as its biosecurity implications.

Frank Lemckert has assembled and sent out data on the conservation status of all Australian frogs in preparation for a workshop to re-evaluate their status. The workshop will be held during the annual meeting of the Australian Society of Herpetologists at Paluma, Queensland between November 8 and 11. We are hoping that we will make sufficient progress during the workshop that after a second round of comments we will be able to submit status updates for the Australian fauna to IUCN.

Ross A. Alford (Chair) Australian Amphibian Specialist Group.

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Indonesia

The Indonesian IUCN SSC Amphibian Specialist Group currently has seven active members. Our research activities have focused on a range of amphibian species, including the lungless frog, *Barbourula kalimantanensis* which was spectacularly rediscovered during an expedition to central Kalimantan on Borneo (Bickford et al. 2008). This is the first case of complete lunglessness reported in a frog (Bickford et al. 2008) and further research has revealed that this species diverged at least 10 million years ago (Blackburn et al. 2010). Intensive works around the distribution range of *B. kalimantanensis* have shown that the species is not as rare as previously thought, but more likely the difficulties in locating individuals are due to its elusive behavior. The species has been found in seven localities and more than five watersheds. As a result, its conservation status has been proposed to be downgraded from Endangered B2ab(iii) to Vulnerable B1ab(iii) (Rahmayuningtyas et al 2011).

Dicroglossid frogs have also been the focus of intensive research since early 2000 across Indonesia, primarily on Sulawesi but also Sumatra and Borneo (Emerson et al. 2000; Evans et al. 2003; Setiadi et al. 2011). As a result of these efforts, many undescribed species have been revealed by molecular studies however not yet substantiated with a complete revision of the group. At least three species have been published this year, one from each of the larger Sunda Islands (Iskandar et al. 2011a; Iskandar et al. 2011b; McLeod et al. 2011). Another study

revealed that *Staurois natator* actually comprised of three species and led to the recognition of *S. guttatus* and *S. nubillus* (Arifin et al. 2011). In addition, following the Evolutionary Species Concept, Riyanto et al. (2011) have recently described the Sulawesi population of the *P. leucomystax* species complex as a new species.

Swei et al. (2011) recently published their findings on the distribution of the disease chytridiomycosis (*Bd*) in Asia, concluding that the low presences of *Bd* in the region suggests it is either newly emerging in Asia, endemic at low prevalence, or that some other ecological factor is preventing *Bd* from fully invading Asian amphibians. A synopsis of this study can be read in FrogLog vol. 98. Kusriani et al. have been involved with the monitoring of chytrid in Indonesia, their findings of samples taken at Mount Gebe Pangrango can be read in Kusriani et al. 2008.

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McGuire.**

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FrogLog Schedule

January 2012 - South America
March 2012 - Europe, North Africa and West Asia
May 2012 - North and Central America and the Caribbean
July 2012 - Sub Saharan Africa
September 2012 - Mainland Asia
November 2012 - Maritime Southeast Asia and Oceania
January 2013 - South America
March 2013 - Europe, North Africa and West Asia



Robin Moore / iLCP

New Zealand

Despite having over 100 species of reptiles, New Zealand is home to only four species of indigenous amphibians. These all belong in the Genus *Leiopelma* which is the basal lineage of all modern anurans. They certainly are *strange* frogs and some aspects of their life history seem more aligned with salamanders than frogs. The New Zealand government oversees the protection of these frogs through their Department of Conservation (DOC), as they are covered under the Wildlife Act, and the frogs are considered 'taonga' (living treasures) by the indigenous Maori people. Any manipulations of wild frogs (even looking for them in the wild) in New Zealand requires a permit from DOC and permission from the local Maori tribe. DOC published a Native Frog Recovery

Plan in 1996 (Newman 1996) and this has been reviewed and a completely updated plan incorporating many of the ACAP themes is due to be published later this year. Frog conservation research in New Zealand has focused on chytridiomycosis, translocations and reintroductions, population demographics, captive breeding, and the effects of introduced mammalian predators.

In addition to the indigenous frog species, three Australian hylid frogs (*Litoria aurea*, *L. raniformis*, *L. ewingii*) were introduced in the late 1800s (by the Acclimatisation Societies) and successfully managed to colonise their new habitat. Two of these species (*L. aurea*, *L. raniformis*) continue to be widespread in New Zealand but are threatened in their native Australian habitats. Although they have been documented as a predator of the *Leiopelma*

frogs, this is not considered to be significant as their preferred habitats do not often overlap.

Frog conservation research is currently conducted by Auckland Zoo, EcoGene, Landcare Research (Auckland), Massey University (Albany), University of Otago and Victoria University of Wellington (for more information please visit www.nzfrogs.org).

Captive frog breeding facilities exist at Auckland Zoo (Archey's frogs) and Hamilton Zoo (Hochstetters frogs) and are being built at Orana Wildlife Park (Christchurch). *Leiopelma pakeka* has been captive bred in the Zealandia sanctuary (Wellington), while the Orana Wildlife Park facility intends to start with *L. pakeka* in preparation for taking on the more endangered *L. hamiltoni* if necessary. The Orana Wildlife Park frog breeding facility is in its final stages, but the going has been tough. Shortly after throwing the foundations of the facility Christchurch was hit with a massive 7.1 magnitude earthquake in 2010 and then once construction had just resumed another devastating magnitude 6.3 earthquake hit 5 months later. The breeding facility survived with minimal damage (Figure 1), however tourism in Christchurch has taken a severe hit and gate sales are very low, as the locals understandably have more pressing issues to attend to. So if you ever find yourself in Christchurch, please show your support and check out the new frog breeding centre (www.oranawildlifepark.co.nz). Wellington Zoo has constructed outdoor frog enclosures in anticipation of acquiring *L. pakeka* for a future conservation breeding programme.

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Further updates from New Zealand can be found on page 32.



Figure 1: Captive frog breeding facilities at Orana Wildlife Park, Christchurch. Photo: Nathan Hawke.

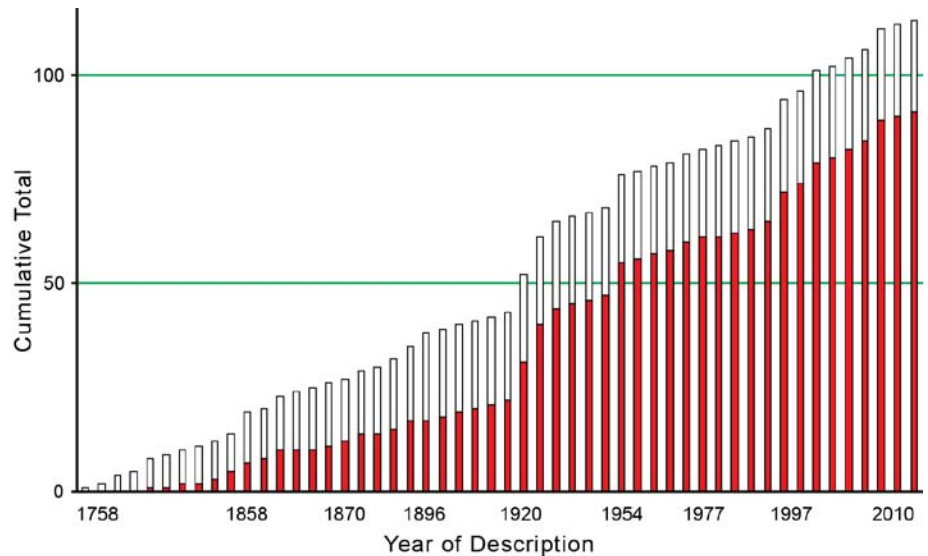
Philippines

Revived interest in Philippine herpetological research

Beginning in the 1990s, more than a dozen international and Philippine-based institutions and research organizations became involved in herpetological research in the Philippines. This is a big leap from post-World War II efforts wherein only a handful of institutions (in particular, the Silliman University, Stanford University, California Academy of Sciences, National Museum of the Philippines, Field Museum of Natural History, and Mindanao State University) were directly involved in field research.

As a result of a revitalized interest on Philippine herpetology, a series of herpetological surveys were undertaken in many areas across the country. These systematic field surveys have resulted in the discovery of an astonishing number of undescribed species. In the past two decades, 29 new species of frogs were added to the amphibian fauna and a remarkable number of additional new species (over 30 species based on current estimates) remain to be described.

With each intensive survey conducted in unexplored or incompletely surveyed forest habitats that are found in isolated mountains and mountain range, new species continue to be discovered. For example, since 2009 joint expeditions conducted by



The diversity and level of endemism of Philippine amphibians continue to increase with discoveries of new taxa.

herpetologists of the National Museum of the Philippines and the University of Kansas have found no less than 10 species of frogs that are new to science. In addition, several “lost” amphibian species—those that have not been seen again since they were first discovered between 30 and 80 years ago—were rediscovered during the last decade through efforts to revisit type localities. Among those that were found include some of the most enigmatic species known from the Philippines, such as *Barbourula busuangensis*, *Sanguirana igorota*, and *Ichthyophis mindanaoensis*.

To date, 108 species (excluding five species of frogs that have been introduced by man) are known from the Philippines, of which 84% (91 of 108 species) are endemics. The completion of ongoing taxonomic and revisionary works on several groups of amphibians is estimated to increase species diversity by at least 40%.

It is clear that Philippine amphibian diversity remains underestimated. Philippine herpetology is experiencing another age of discovery and we anticipate that intensive field surveys of freshwater ecosystems, mountain massifs, and mountain range systems will result to additional records of species and the discovery of an impressive number of new taxa.

Immediate needs

Initial results of the region-wide collaborative research on the distribution and impact of the chytrid fungus *Batrachochytrium dendrobatidis* in Southeast Asia has been productive. Ongoing studies in the Philippines will further determine the distribution and the extent of chytrid infection among local frog species.

There is an immediate need for increased action both in basic field research and conservation work. Little progress has been made on research and conservation efforts that center on threatened amphibians and their habitats, especially in light of the continuing massive degradation of critical ecosystems. Studies on life history, foraging behavior, reproductive biology, and population ecology most especially of endemic species, are crucial in order to generate essential data for practical application in conservation and



Among the new species found in the last two decades include *Sanguirana aurantipunctata* (top left, Photo: RM Brown) and *Platymantis biak* (top right, Photo: AC Diesmos), both are threatened by continued habitat loss and degradation. *Barbourula busuangensis* (bottom left) and *Sanguirana igorota* (bottom right) are among the species that were rediscovered in recent field surveys. Photos: AC Diesmos.

management. At the same time, there is a need to encourage and recruit Filipino students who are interested in amphibian research, with the ultimate goal of creating a pool of biodiversity specialists. These are among the greatest challenges that need to be dealt with proactively.

Acknowledgements

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Singapore

Singapore as Type Locality

The taxonomic significance of Singapore as the type locality for a broad spectrum of native animals cannot be underestimated or overemphasized, as a long list of species have actually been first described as new to science based on specimens from here over the last century. These include three species of amphibians: one caecilian and two frogs. The caecilian was described and

named *Ichthyophis singaporensis* by E. H. Taylor in 1960, based on an adult holotype which presently resides at the Natural History Museum, London. The Black-eyed Leaf Litter Frog, *Leptobrachium nigrops* Berry & Hendrickson, 1963 (Fig. 1) was described from freshwater swampforest in the heart of the island. The Malesian Frog, *Limnonectes malesianus* (Kiew, 1984) (Fig. 2) was described from the lowland hill forests of Bukit Timah Nature Reserve. While local populations of both frog species remain healthy, the Singapore Caecilian has yet to be sighted since and remains elusive, despite attempts by herpetologists to search for it.

Research Progress

In the past two decades, progressive investment of time and effort into field surveys has proven to be fruitful. New records for Singapore have been documented, such as the Thorny Treefrog, *Theloderma horridum* (Leong et al., 1996), as well as Manthey's Narrow-mouthed Frog, *Microhyla mantheyi* (Leong & Chou, 1997: as *Microhyla borneensis*). Until recently, the Thorny Treefrog was presumed to be confined to Bukit Timah Nature Reserve, but is now confirmed to occur in the Nee Soon swampforest as well (Figueroa & Selveindran, 2011). Detailed taxonomic investigations into the *Rana baramica* complex (Fig. 3) has resulted in the elevation and recognition of *Rana laterimaculata* as a morphologically distinct species (Leong et al., 2003).

Struggle to Survive

For the 27 species of native amphibians, continued survival within Singapore may

be fraught with a host of challenges and difficulties. On this island nation of around 700 square kilometers, more than 5 million people jostle for space to live, work, play and commute. With existing forest cover occupying just 3% of the land area, these habitats are most precious, especially for the forest-specific species which constitute ca. 70% of the frog fauna. As the country continues to prosper and progress amidst a vibrant economy, numerous large-scale development projects have been picking up momentum. Inevitably, some of these projects may be situated in close proximity to the Nature Reserves and become potential sources of disturbance and/or pollution. While conducting a freshwater stream survey in May of 2009, we were dismayed to witness forest frogs smothered with sticky mud and silt, unlike anything we had ever seen before (Fig. 4). Disturbed and distressed by this unfavorable scenario, the source of this pollution was eventually traced to excavation works uphill and upstream of this tributary network. The relevant authorities were immediately informed and the guilty party was dealt with accordingly. Fortunately for the frogs and all the other stream inhabitants, a subsequent series of rains helped to progressively flush most of the mud away.

In the preceding decades, Singapore has not been immune to the ramifications of climate change. Meteorological records have shown that mean temperatures have been climbing steadily, with prolonged dry periods. With the vast majority of Singapore's frogs highly reliant on adequate rainfall to feed their streams and fill their puddles, their window period for successful reproduction may



Fig. 1: Black-eyed Leaf Litter Frog, *Leptobrachium nigrops*. Photo: Celine Low (top left). Fig. 2: Malesian Frog, *Limnonectes malesianus* (top right). Fig. 3: Unmasked Rough-sided Frog, *Rana baramica*. Photo: Leong Tzi Ming (bottom left). Fig. 4: Malayan Giant Frog, *Limnonectes blythii* smothered in mud. Photo: Vilma D'Rozario (bottom right).



Fig. 5: Black-spotted Sticky Frog, *Kalophrynus pleurostigma*, eggs in treehole. Photos: Vilma D'Rozario & Leong Tzi Ming.



Fig. 6: Günther's Frog, *Hylarana guentheri*. Photo: Leong Tzi Ming.

thus be limited. An example of a vulnerable species that is particularly dependant on precipitation would be the Black-spotted Sticky Frog, *Kalophrynus pleurostigma*, as it breeds in phytohelms such as treeholes (Fig. 5). Recent experimental studies to provide artificial breeding receptacles for this species proved to be a success, as the frogs were highly receptive to such alternative oviposition sites (Teo, 2010).

Another challenge that native frogs may be faced with are alien species, which could compete for a similar niche and resources. One example of an introduced resident is the Günther's Frog, *Hylarana guentheri*

(Fig. 6), which has established populations in the western parts of the island (Leong & Lim, 2011). When threatened, this frog will elevate and inflate itself, accompanied with foul skin secretions. Such effective defensive strategies may provide the species with a certain degree of immunity against local predators. Continued monitoring of this species would be necessary to ensure that its population does not expand exponentially.

Education and Outreach

As part of the 'Year of the Frog' initiative of 2008, the Singapore Zoo produced a colourful poster on our local species (Fig.

7 see next page), with copies distributed to schools and participants of amphibian awareness activities.

An article in the national newspaper was also published to draw readers' attention to the plight of global amphibians (Leong, 2008). In the quarterly magazine of the local conservation NGO, Nature Society Singapore, a comprehensive article was also dedicated to such a topic (Leong, 2009). At the Sungei Buloh Wetland Reserve, a series of amphibian talks was conducted, accompanied by the initiation of a comprehensive frog survey within the reserve which involved a team of local volunteers (Chan & Goh, 2010).

Tadpole Tales

Oftentimes, the larval stages of frogs are either overlooked or understudied, but are in fact a crucial component of their amphibious life cycle. During this aquatic phase, tadpoles are vulnerable to changes in water levels, water quality, food availability, and predation pressure. Among Singapore's frogs and toads, their tadpoles are manifested in a spectrum of morphological and ecological diversity, represented by different forms to best suit their respective microhabitats (Leong & Chou, 1999; Leong, 2004). One example of a unique tadpole is that of the Horned Frog, *Megophrys nasuta*. It has the habit of beaching itself along the stream banks and feeding on floating organic matter with a wide, upturned mouth (Fig. 8). In recent years, this particular species has been observed to have a range contraction, as localised populations disappear from particular streams that may be relatively shallower and shorter. These smaller streams have become more susceptible to dry spells with increasing frequency and hence unable to provide adequate microhabitats for the Horned Frog tadpoles.

Moving up to the forest vegetation, arboreal species often rely on phytohelms for their reproduction. This includes the Saint Andrew's Cross Toadlet, *Pelophryne signata* (Fig. 9), which is currently known only from one valley in Bukit Timah Nature



From left to right - Fig. 8: Tadpole of Horned Frog, *Megophrys nasuta*. Fig. 9: Saint Andrew's Cross Toadlet, *Pelophryne signata*. Fig. 10: Advanced tadpole of Saint Andrew's Cross Toadlet. Note abundant yolk. Fig. 11: Masked Swamp Frog, *Limnonectes paramacrodon*. Photo: Leong Tzi Ming.

Frogs and Toads of Singapore

Help Them Leap Away From Extinction



Cause for Concern

About 1/3 of our planet's amphibians are threatened with extinction by deforestation, pollution, habitat loss and the chytrid fungus. Climate change alters rainfall patterns, which in turn affect the breeding cycles of amphibians.

2008 is the Year of the Frog. Zoos and wildlife organizations are working together to help amphibians leap away from extinction.

This poster features 25 species of frogs and toads found in Singapore. Do your part to ensure that they will be around for the longest time to come.

- Learn more about amphibians to understand them better
- Create frog-friendly habitats in your home or school
- Keep water bodies clean. Amphibians deserve a clean home
- Do not release your pet fish or frog into our nature reserves. Alien species may 'bully' native animals and threaten their survival

Important Amphibians

- Amphibians have a thin layer of skin and many live on land and in water. Pollutants in the environment can enter their body readily through the skin. Their health tells us a lot about the quality of our land and aquatic environment.
- Amphibians are a source of food for snakes, fish and birds.
- Amphibians feed on insects and other invertebrates, helping farmers keep pests away. They also help control mosquito populations. Yet another reason to save amphibians.



For more info, please visit www.zoo.com.sg/frog

Photo of Thorny Tree Frog by Norman Lim; all others by Leong Tzi Ming (Chairperson: ASG Singapore). Layout by Chris Sam Ngan Yin © Wildlife Reserves Singapore 2008.

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Fig. 7: Singapore Frog Poster, produced in 2008 to commemorate the 'Year of the Frog'.



Fig. 12: Spotted Treefrog, *Nyctixalus pictus*. Photo: Leong Tzi Ming.

Reserve. Recently, we have been delighted to document their tadpoles growing up in treeholes (Leong & Teo, 2009). The nutritional mode of this tadpole may be regarded as being endotrophic, as they are able to complete metamorphosis without having to feed at all and deriving sustenance entirely from maternal yolk (Fig. 10).

Local observations of tadpole predation have been few, but include aquatic insects such as water scorpions and odonate nymphs. Certain snakes may also feed on tadpoles opportunistically (Leong et al., 2009). Not all the tadpoles in Singapore have been elucidated. The exact larval identities of two species remain to be revealed, including the Unmasked Rough-sided Frog, *Rana baramica*, and the Masked Swamp Frog, *Limnonectes paramacrodon* (Fig. 11). As both species are predominantly swamp dwellers, it is most likely that their tadpoles live and hide amongst the water-logged tangle of leaves, roots and organic sludge, making the search for them a challenging exercise.

Anuran Symphony

Any study on frogs and toads would be incomplete without a fundamental recognition of their diverse call characteristics. Among the host of Singapore's anuran musicians, some species may be capable of performing surprisingly melodious tunes. One example is the shy, forest-dependant Spotted Treefrog, *Nyctixalus pictus* (Fig. 12), which has been known to have a repertoire of soft, whistling notes. Another of my personal favorites is

the pleasant sequence of biphasic calls produced by the Four-ridged Toad, *Bufo quadriporcatus* (Fig. 13), which is always music to my ears. The onset of our monsoon seasons, accompanied by exceptionally heavy rains, is often always announced by the deep groans of the Banded Bullfrog, *Kaloula pulchra* (Fig. 14). Each time they inflate their enormous vocal sacs, ripples of resonance radiate outwards, eliciting responses from competitive males or receptive females. I sincerely hope that our native frogs will continue to sing and thrive in their remnant habitats, despite the looming pressures and challenges from development and climate change, for without them, Singapore's night life will be less varied and vibrant!

Acknowledgements

I am grateful to HSBC (Singapore) for their commitment to local biodiversity conservation and demonstrating a concern



Fig. 14: Banded Bullfrog, *Kaloula pulchra*. Photo: Leong Tzi Ming.

for the sustainability of natural ecosystems. I appreciate the determination of Tony O'Dempsey, whose efforts to trace the source of stream pollution helped improve the water quality for its amphibian inhabitants. I thank Celine Low and Vilma D'Rozario for their faithful field assistance and generosity in sharing their frog images. The Natural History Museum (London) and Field Museum of Natural History (Chicago) kindly granted permission to examine the historical amphibian specimens in their collection. I wish to dedicate this article

to Robert F. Inger, who has studied the amphibians and reptiles in the region for more than half a century, and continues to be an encouragement and inspiration to any herpetologist who has had the privilege of working with him.

Leong Tzi Ming (Chair), Singapore Amphibian Specialist Group.

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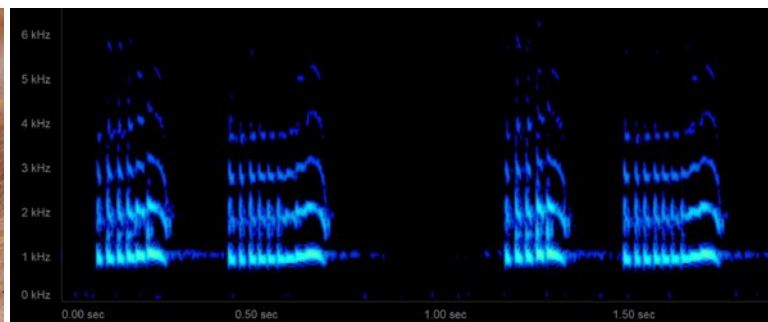


Fig. 13: Four-ridged Toad, *Bufo quadriporcatus* and sample spectrogram of its call structure. Photo: Leong Tzi Ming.

NSW Declining Frog Working Group

By Frank Lemckert & the NSW DFWG

Over the last six years or so, a somewhat eclectic group of people have been meeting to discuss and provide advice on the latest issues in frog conservation in New South Wales. This group is known as the NSW Declining Frog Working Group, or the DFWG, meets twice a year and has no fixed membership. Anyone with a demonstrated interest in frog conservation is able to attend meetings and, although there is a core group of scientists and conservation officers, meetings regularly include environmental consultants, students and zoo staff. To assist a range of views and ideas to be covered over time, the meetings are constantly moved around the state and have been held not only in major cities such as Sydney and Canberra, but have also been held in the far north and far south of NSW. People from outside of NSW also attend, with the Australian Chair of the Amphibian Specialist Group, Ross Alford, travelling all the way from northern Queensland to be part of the last meeting. Of particular note is that the group is now the only regularly convening broad issue based frog conservation group within Australia and it plays an important role in advising both NSW and Australian government departments on current problems regarding amphibians.

The origins of the group can be traced to several frog recovery teams and a NSW government declining frog group that operated within NSW in the late 1990s. These groups played a role in developing recovery plans implementing recovery actions for species of frogs listed under the NSW Threatened Species Act. However, these teams gradually dissolved, leaving only the corroboree frog recovery team operational and a void in general frog conservation activities. In 2006, Deborah Ashworth of the then NSW National Parks and Wildlife Service asked Michael Mahony and myself about the idea of starting up a new working group. We agreed to do so on the basis that the group would have some independence and any interested persons would be allowed to attend meetings and the idea was met with considerable enthusiasm by people working in the area. A first meeting was held in late 2006 to further develop the idea and the DFWG took its final form in May 2007 at a meeting where it was agreed that it would be an independent group, with no official government affiliation, allowing it to provide independent comment on any issue. This means that it does not receive any specific government support, yet its status is such that it has not been hard to get sponsorship to cover the costs of meetings wherever they are held.

The DFWG may have no official or formal standing, but is recognised as an expert body by a range of government departments and meetings are well attended by many land management officers seeking advice on amphibian conservation. Meetings start with all present providing summaries of recent activities on the frog conservation front to keep everyone informed

of what is happening around the state. Students involved in frog conservation are encouraged to attend to provide updates on the most recent research and this also provides them with an opportunity to network with the scientists and managers attending the meetings. Meetings generally have a central theme, which have included amphibian monitoring, frog conservation status, translocation policies, threats to inland frogs, climate change impacts, cane toads and the chytrid fungus. These have been particularly valuable in providing managers with the latest information on each of these themes to assist in the development of their planning processes.

The DFWG has no specific aims beyond providing information and advice on frog conservation issues to all people attending and to provide comment on issues as an expert body. It has no statutory standing or legislative “teeth” and so does not attempt to enforce any actions. Rather it provides guidance to assist other groups to formulate their own plans and actions and provides impetus for changes to be made. Recently the group has provided a review of the Australian Cane Toad Threat Abatement plan, noting its lack of focus on NSW and written to raise concerns over the impacts of feral horses on the habitat of the now very seriously threatened species of corroboree frogs. Two notable successes have been:

Highlighting the taxonomic uncertainty of the last individuals of *Mixophyes balbus* found in the southern part of the state, leading to funding of a genetic study that split the species in two.

The rediscovery of a population of the highland bell frog (*Litoria castanea*) by one of the members of the DFWG (after a lot of discussion as to whether this was possible – credit to you Dr Hunter)

Meetings of the DFWG continue to be well attended, with over 30 people present at the last meeting, held in Canberra, where representatives of the Federal Department of Sustainability, Environment, Water, Population and Communities provided the group with a thorough overview of the Australian Government’s approach to frog conservation. In turn the group was able to highlight how this integrated (or did not integrate) with the NSW legislation and processes and provided everyone with a better understanding of how to achieve better conservation outcomes. In the near future the DFWG is looking to be the catalyst for a major review of frog conservation in Australia through the organisation of a new Declines and Disappearances of Australian Frogs workshop, following on ten years after the first. A revision of the IUCN status of Australian frogs has also been proposed and should be completed after a workshop is held at the November meeting of the Australian Society of Herpetologists.

Development and application of Assisted Reproductive Technologies (ART) for the conservation of Australian anurans

By Aimee Silla

Assisted Reproductive Technologies (ART), including the hormonal induction of gamete-release, genetic resource banking and *in-vitro* fertilisation (IVF), have enormous potential to assist the propagation and genetic management of the worlds declining amphibian species. To date, however, few studies have attempted to apply ART to Australian anurans, and the success of such studies has been limited and highly species-specific. The collection of large quantities of good quality spermatozoa and oocytes is fundamental to ensuring successful fertilisations and improved survivorship of offspring generated by ART. Consequently, research into the development of reliable and effective gamete-release induction protocols for a range of Australian anuran species is currently being undertaken.

Natural gamete-release in anurans is dependent on the secretion of luteinizing hormone-releasing hormone (LHRH) from the hypothalamus, which stimulates the synthesis and release of luteinizing hormone (LH) and follicle-stimulating hormone (FSH). Circulating LH and FSH bind to target receptors on the gonads, resulting in the release of sex-steroids and inducing gametogenesis and gamete-release. Two main exogenous hormones are commonly used to artificially induce gamete-release in anurans: LHRHa, which aims to stimulate the natural release of LH; and hCG, which mimics the structure and function of LH. Research has been conducted to investigate the efficacy LHRHa and hCG at inducing spermiation (sperm-release) in a number of Western Australian myobatrachids (Silla & Roberts unpublished) and highlights the species-specific nature of spermiation responses.



Pseudophryne guentheri - female being gently squeezed to expell oocytes. Photo: A J Silla

To further investigate hormonal induction protocols, the terrestrial toadlet, *Pseudophryne guentheri* has been employed as a common model species to quantify the spermiation response of males administered varying doses of LHRHa and LHRHa in combination with AVT (Silla, 2010). The species has also been used to investigate the



Pseudophryne guentheri - A common model species. Photo: A J Silla

effects of LHRHa priming on spermiation and ovulation (Silla 2011) and to quantify optimal IVF protocols to maximise fertilisation success (Silla unpublished). These studies led to a collaboration between Aimee Silla (University of Western Australia) and Dr Phillip Byrne (University of Wollongong) applying ART to the critically endangered Southern Corroboree Frog, *Pseudophryne corroboree*. Captive *P.corroboree* colonies established from natural clutches collected by Dr Dave Hunter (Office of Environment and Heritage) and maintained by Dr Gerry Marantelli (Amphibian Research Centre, Melbourne) and Dr Peter Harlow and Michael McFadden (Taronga Zoo, Sydney) have been employed to hormonally induce gamete-release and attempt IVF (Byrne & Silla 2010). Initial results from this research have been encouraging, although further research is required before viable offspring are generated using ART in this species.

Another priority area is to investigate the efficacy of alternative hormone administration protocols, aimed at minimising discomfort, in small species. A collaborative project between the University of Western Australia and Perth Zoo employed the small (19-25, SVL) direct-developer *Geocrinia rosea* to quantify the spermiation response of males administered hCG and LHRHa via sub-cutaneous injection or topical application (Silla, Robertson & Roberts unpublished). Results from this study show, for the first time, that topical application of LHRHa can be as effective as hormone injection when appropriate doses are applied. Efforts are currently underway to establish an amphibian ART research program headed by Aimee Silla and Dr Phillip Byrne based at the University of Wollongong. Research at the University of Wollongong recently commenced on the critically endangered Booroolong Frog, *Litoria booroolongensis*, reared in captivity by Dr Peter Harlow and Michael McFadden (Taronga Zoo, Sydney). Initial work with the species has included quantifying the spermiation response of males to varying doses of LHRHa. Further research will be conducted next year investigating the

effect of dopamine antagonists on spermiation and optimising short-term sperm storage protocols. Additionally, a collaboration between Aimee Silla and Dr Phillip Byrne of the University of Wollongong, and Dr John Clulow of the University of Newcastle will commence in 2012 to investigate cryopreservation techniques for the long-term storage of *L.booroolongensis* sperm. Australian research in amphibian ART is still in its infancy, however initial results have been important in solidifying the potential of ART to assist with the future propagation of our endangered species.



Pseudophryne bibronii - developing embryo generated by IVF
Photo: A J Silla

Acknowledgments

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Green and Golden Bell Frog Research at the University of Newcastle

By Deborah Bower

The green and golden bell frog is both invasive and threatened providing an interesting model for ecological research and a challenge to conservation. Researchers at the University of Newcastle have been studying bell frogs under the direction of Mike Mahony and John Clulow since 1996. The research has focused primarily on two populations on the east coast of Australia, providing some long term data that has both enlightened and confused us.

Historically, bell frogs were considered the most common frog in Sydney. Gerald Krefft recollects in his early encounters with Sydney frog assemblages "*Hyla aurea* is the most common of all Australian frogs, being found in every lagoon or stream of water and furnishing food to the Black Snakes, which swallow this *Hyla* as a gourmand does an oyster". They were even collected for dissection practicals at several universities during the day when they sat out basking. But since the 1970s the bell frog's distribution retracted to approximately 40 small and discrete populations. Interestingly, these populations are often found in historically polluted sites such as Sydney Olympic Park, once a complex of the NSW State Brickworks, State Abattoir and heavy industry. This site was rehabilitated in the 1990's and is located

in the middle of Sydney, providing a unique opportunity for restoration ecology and adaptive management. But first we need to know, why do bell frogs persist in isolated populations?

It appears that the infamous chytrid fungus has spared no bell frog prisoners. Bell frogs are extremely susceptible to chytridiomycosis, which kills individuals in mainland populations of the bell frog (Stockwell 2011). The effects on bell frogs are more severe than when sympatric species harbour the fungus (Stockwell 2008, 2010). Instead of maintaining low zoospore counts, bell frogs succumb to the disease over winter when temperatures are optimal for chytrid growth. Researchers are quantifying seasonal variation in survival through extensive mark-recapture and radio-tracking studies to find out exactly how low annual survival is and how this affects the long term viability of the populations (Pickett 2009).

Fortunately, bell frogs are highly fecund and grow extremely fast (Hamer et al. 2007). Just like a weed. Females at Sydney Olympic Park lay 3500 eggs over a wide variety of pond habitats (Christy 2000). Breeding occurs over an extended period, during the southern spring-summer (September to February). During

breeding the male frogs aggregate in large, connected ponds and chorus together. The conspecific attraction by mature individuals over the breeding season produces aggregated distributions in low density populations, but may mitigate allee effects.

Considerable research attention has been devoted to the question of determining the habitat requirements of the frog and its tadpoles, especially in the sites where populations persist compared to the many sites from where it has disappeared. Because several bell frog populations occur in and near industrial areas with disturbed habitat, the habitat features that influence the population size has been studied on many different scales (Garnham 2009; Midson 2009; Pollard 2009; Hamer 2010). It is perhaps not surprising that we have not obtained a definitive solution to the ideal habitat recipe, because the species is a generalist in so many other ways. Habitats differ across sites from small streams to sparsely vegetated ponds, to productive ponds with healthy riparian zones (Patmore 2001). Even within similar habitats the choice of vegetation is not always clear. The clue to current habitat use appears to be in the facilitation affect of some habitats in reducing the impact of chytrid on the frog and its tadpoles.

Bell frog reintroductions to new habitats have failed because of the influence of chytrid (Stockwell 2008). However, chytrid inhibitors in the environment, such as low concentrations of salt in the water, are being trialled to assist populations in establishing. While this is appearing successful, its use in restoration biology requires careful consideration. Researchers at the University of Newcastle are studying the effect of salt and chytrid stress on the development of frogs to look at the comparative influence.

Another factor that has been implicated to constrain population regulation is the plague minnow (*Gambusia holbrooki*) - a

small invasive fish that occurs throughout the bell frog's range (Hamer 2002). Managers at Sydney Olympic Park recognised the potential effects of the plague minnow, which predate on eggs and tadpoles, and implemented a draining regime in a subset of ponds (Darcovich and O'Meara 2008). This information is being used to assess the influence of pond draining on bell frog reproduction.

Whilst we have learnt a great deal about bell frogs in the past fifteen years, much of their basic biology has eluded us. We still have so much to learn about how to successfully create habitat, the factors that regulate demography in the population, the physiological implications of different stressors, and the influence of behaviour on population distribution. Fortunately, the green and golden bell frog is charismatic and secured its fame in the lead up to the Olympics, making it iconic and special in the eyes of many Australians. We hope that by working with managers we can restore the species to its former glory and provide a model for restoration of other threatened amphibians.

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The green and golden bell frog (*Litoria aurea*) is both invasive and threatened providing an interesting model for ecological research and a challenge to conservation. Photo: D. Bower

Zoos Victoria supporting conservation of threatened native Australian frogs

By Chris Banks

Zoos Victoria, a statutory authority overseeing management of Melbourne Zoo (MZ), Healesville Sanctuary (HS) and Werribee Open Range Zoo (WORZ), has been supporting the conservation of threatened native Australian frogs for many years. Captive breeding, training and other in-kind support has also supported amphibians in Hong Kong, Philippines and India (Afuang et al., 2002; Banks, 1999; Banks et al., 2008; Lau & Banks, 2008).

Specialised breeding facilities have been established at MZ and HS; whilst the focus at WORZ is protection of a naturally-occurring wild population of Growling Grass Frog, *Litoria raniformis*, which is listed as Vulnerable in Australia and Endangered by the IUCN.

Current programs - Active programs are in place for three species and are well-advanced to support a fourth. These have varying combinations of *in situ* and *ex situ* management: **Spotted Tree Frog, *Litoria spenceri* (IUCN Critically Endangered):**

A range of threats including chytrid fungus, predation by introduced trout and habitat disturbance, are link to the decline of these frogs throughout their range. They are now limited to a few reaches of rocky mountain streams in north-eastern Victoria and adjoining New South Wales.

Zoos Victoria's roles in the Spotted Tree Frog Recovery Program, commencing in 1991, are to:

- Maintain an insurance population in captivity
- Help with population monitoring programs (including reintroduction trials)
- Increase community awareness and support for the Spotted Tree Frog.

Since 2009, we have also been undertaking field research to understand the relative demographic significance and potential interactive impacts of trout and chytrid fungus on the Spotted Tree Frog and Rocky River Tree Frog (*Litoria lesueuri*). This information will then be used to review the current status and distribution of the Spotted Tree Frog and develop effective conservation management strategies.

A captive breeding program was initiated at Healesville Sanctuary in 2007 to produce animals for experimental release. The aim of these experiments is to investigate factors affecting survival of tadpoles and metamorphs, as these life stages appear particularly vulnerable to threatening processes which limit population growth rates.

Zoos Victoria is also funding a review of the current distribution of the species, during which the species status and threats



Spotted Tree Frog with Matt West during PhD fieldwork funded by Zoos Victoria. Photo: Zoos Victoria.

throughout its known range will be assessed. This review will allow us to update the conservation status of the species. The last thorough assessment of the species was undertaken between 1992 and 1998 (Gillespie and Hollis 1996, Gillespie 2001) and it's intended that the results of this latest assessment will be available in early 2013.

Southern Corroboree Frog, *Pseudophryne corroboree* (IUCN Critically Endangered):

This is a habitat specialist, only occurring at high altitudes (>1200 m above sea level) in the Snowy Mountains region of Kosciuszko National Park, New South Wales. The frogs breed in boggy shallow pools or seepages, females laying their eggs in small nests. The adult frogs over-winter in adjacent forests and tall heaths, moving back to the bogs in January/February.

Chytridiomycosis is the primary factor causing the decline of the species. Climate change is also having an impact and this



Southern Corroboree Frog public display, with rearing/breeding tanks. Photo: Zoos Victoria.

CONSERVATION IN ACTION
www.zoo.org.au/conservation

FIGHTING EXTINCTION
ZOOS VICTORIA

Stuttering Barred Frog Recovery

In the early 1980's the Stuttering Barred Frog was often heard, from northern New South Wales to north-eastern Victoria. Today it has become increasingly scarce and could be extinct in Victoria.

Disease, habitat loss, pollution, increased ultra-violet light (due to reduction of the ozone layer) and introduced species are all reasons for the decline of this valuable frog.

In February 2001, with the help of the Northeast NSW Threatened Frog Recovery Team, a number of frogs were brought to Melbourne Zoo. Zoo keepers, Russell Traher and Mike Swan, collected 4 males, 3 females and 20 tadpoles from the Tinarra Plateau in northern New South Wales.

All of the frogs collected have bred successfully here at the Zoo, helping to secure the future for the Stuttering Barred Frog in Victoria.

"The Stuttering Barred Frog was once found in Victoria, but it has not been seen or heard here since 1982. This species is threatened throughout its whole range and is now a priority for captive breeding at Melbourne Zoo."

Russell Hobbs, Keeper
Melbourne Zoo





Frog, *Mixophyes fasciolatus*, with regular captive breeding subsequently achieved (Banks et al., 2003).

Left. Stuttering Frog information panel. Photo: Chris Banks.
Above. Stuttering Frog. Photo: Damian Goodall.

That success facilitated a program of collecting Stuttering Frogs (*Mixophyes balbus*) from the northern part of the species' distribution. Seven adult frogs and 20 tadpoles were collected in February 2001, and repeated captive breeding has been achieved at MZ since (Traher et al., in prep.).

is expected to worsen, particularly if droughts become more frequent or there is less rainfall (Hunter 2010). The warming climate is causing the ephemeral breeding pools to dry out during droughts and before tadpoles complete metamorphosis.

Zoos Victoria's key roles in the Southern Corroboree Frog Recovery Program are to:

- Maintain an insurance population in captivity
- Supplement wild populations through captive breeding for reintroduction
- Assist with population monitoring
- Increase community awareness and support for the Southern Corroboree Frog

The wild population is continuing to decline and results of the last field survey (2010-2011) indicate that there are now less than 50 frogs remaining. The wild population is being supplemented by relocation of eggs in a project that is designed to prevent chytrid fungus infection and pool drying prior to metamorphosis. This project is being undertaken in partnership with Taronga Zoo in Sydney and the Amphibian Research Centre in Melbourne.

Since Melbourne Zoo joined this program in 2005, more than 600 eggs have been laid, leading to 112 tadpoles and 56 frogs metamorphosing. Tadpoles from the 2010-11 season eggs are yet to hatch.

Stuttering Frog, *Mixophyes balbus* (IUCN Vulnerable): Zoos Victoria initiated a captive management program for frogs in the genus *Mixophyes* in 1999, with the goal of developing husbandry protocols for threatened members of this group. The initial work was undertaken with the Great Barred

This species has a wide historic distribution along coastal and hinterland regions of eastern Australia, but has suffered significant declines in recent years, particularly in the south. A recent genetic study has identified two major lineages in this taxon, with significance taxonomic divergence between them (Donnellan, 2008). It has been proposed that the two 'forms' of *M. balbus* be managed separately until this issue is resolved. In light of this and the severe declines across the range of the 'southern form', Zoos Victoria is focussing its efforts on supporting the recovery of these 'southern frogs'. Seven frogs are held at MZ, from 10 tadpoles collected from Macquarie Pass National Park, NSW, in January 2005. Breeding from this group commenced in late 2010, and a proposal for collection of additional representatives of this form is being discussed with relevant researchers.

Baw Baw Frog, *Philoria frosti* (IUCN Critically Endangered):

This species is restricted to approx. 135km² of montane and sub-alpine habitat on the Baw Baw Plateau and adjoining escarpment about 120km east of Melbourne, Victoria. Zoos Victoria has submitted a proposal to collect two egg masses as the first phase of a longer term program to develop husbandry and breeding protocols, with the goal of establishing the capability for wild release.

These frogs have only been held in captivity once previously and, whilst there was good success in raising egg masses and larvae to the metamorph stage, the raising of metamorphs proved more challenging, with relatively high mortality rates. Nine frogs remained alive after four years, but none survived to enable breeding (G Marantelli, pers. comm.). Given the narrow ecological requirements of this species, including its predominantly



Baw Baw Frog. Photo: Greg Hollis

subterranean habit, restricted micro-climatic preferences and unusual life history (Hollis 2004), captive management of these frogs is likely to be a significant challenge.

Annual monitoring of the wild population indicates a continued pattern of decline across the distribution of the species, particularly at sub-alpine elevation (Hollis 2004; Hollis and Scroggie, unpublished data). Factors considered most likely to be responsible for this decline include the presence of chytrid fungus on the Baw Baw Plateau and changes in weather patterns due to climate change (DSE 2011).

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Greg Hollis (Department of Sustainability & Environment, Victoria), David Hunter (Office of Environment & Heritage, Department of Premier & Cabinet, NSW), and Matt West and Raelene Hobbs (Zoos Victoria) updated species information.

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Frog donation panel in Melbourne Zoo's "World of Frogs" complex. Photo: Chris Banks.

Biology and conservation of Fiji's iconic native amphibians

By Dr. Edward Narayan

Fiji Island archipelago consists of 322 small islands located between 176° 53' east and 178° 12' west. There are two iconic amphibian species belonging to the genus *Platymantis* (Family Ranidae, subfamily Platymantines), while a third species *P. megabotoniviti* is extinct. The extinct Fiji frog, *P. megabotoniviti* is believed to have been hunted down to extinction by the first Fiji inhabitants and rats (*Rattus rattus* and *R. praetor*) that had come with them in the late Holocene. Also found in the Fiji archipelago is the non-native cane toad, *Rhinella marina*, which was introduced into Fiji in 1936 to control the insect pests in Fiji's sugar cane fields. Cane toads have been detrimental to native frog populations by preying upon frogs and froglets and competing for food and habitat space, especially with the Fijian ground frog (*P. vitiana*). The Fijian ground frog is currently listed as Endangered (EN B1 + 2C) while the Fijian tree frog (*P. vitiensis*) is listed as Near Threatened (NT) by the International Union for Conservation of Nature (IUCN).



Fijian ground frog (*Platymantis vitiana*). Photo: E. Narayan.



Edward Narayan collecting frog urine on Viwa Island. Photo: E. Narayan.

Over the past decade, research gaps were identified mainly in the knowledge of geographic distributions of native Fijian frogs because of incomplete surveys of several natural habitats. Therefore, more targeted herpetological surveys were undertaken by local scientists to uncover the distribution and abundance of native Fijian frogs. Presently the Fijian tree frog is restricted to four of the largest islands: Viti Levu, Vanua Levu, Taveuni, and Ovalau while the Fijian ground frog is present only on one small site (Waisali forest reserve) on Vanua Levu and four other small islands in the mid-parts of Fiji; Viwa Island in Tailevu; Ovalau and Gau in Lomaiviti group; and Taveuni. All of these four small islands are free of the invasive Small Asian Mongoose (*Herpestes javanicus*) and interestingly there are no cane toads present only on Gau Island. This could be a reason that ground frogs on Gau are much larger in size than their counterparts on other islands.



Eye of the Fijian ground frog (*Platymantis vitiana*). Photo: E. Narayan.

Recently, we have directed immense research focus on understanding the reproductive biology, breeding and physiological stress responses of native frogs within natural habitats, which aims to contribute new knowledge on species biology and species conservation. We studied the early developmental biology of *P. vitiana* revealing some unique embryonic features, especially the vascularised abdominal sacs that are used for respiration in the absence of a vascularised tail or gill arches (Narayan et al. 2011). We have also established non-invasive enzyme-immunoassays for assessing the reproductive hormonal cycles (Narayan et al. 2010a) and stress hormonal

responses (Narayan et al. 2010b) of Fijian ground frogs. These physiological tools can be used to rapidly track the reproductive cycles and the physiological responses of native frogs to anthropogenic changes such as climate change and disease (e.g. chytridiomycosis – a lethal disease caused by the fungal pathogen *Batrachochytrium dendrobatitis*, hereafter referred to as *Bd*). It can also be used for tracking the health status and well-being of native frogs in captivity. We have discovered that the Fijian ground frog population on Viwa Island is at present free of chytridiomycosis. We provided several hypotheses to explain this result such as; 1) hot weather all year round inhibiting the spread of *Bd*, 2) *Bd* may be absent from Viwa Island due to a lack of amphibian introductions (not introduced or importation of exotic frogs such as *Rana catesbeiana*, or *Xenopus* spp or pet trade spp) or 3) the lack of introduction by human vectors due to the geographic isolation, and low visitation of non-local people into the island (Narayan et al. 2011b).

It is crucial to have strong support of the local communities while conducting research in Fiji as they are the spiritual and traditional owners of the land and native fauna. Thus as part of our community based conservation research in Fiji, we have undertaken several projects that are managed by the local people themselves. We have a completed trial project to monitor the annual reproductive cycle of *P. vitiana* on Viwa Island through setting up of barriers to exclude the cane toads from ground frog

breeding sites (see: http://www.ruffordsmallgrants.org/rsg/projects/edward_narayan). Currently, we have undertaken another project to eliminate cane toads from the breeding sites of Fijian ground frogs on Viwa Island. The outcome of this research will help to increase the breeding success of ground frogs and enhance population growth (See: http://www.ruffordsmallgrants.org/rsg/projects/edward_narayan_1). We hope to replicate our projects on other islands with native frogs and promote the biodiversity conservation knowledge enhancement

of the local people. Together, we can work strongly towards saving our native herpetofauna in Fiji Islands.

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Auckland Zoo - Captive Breeding

By Richard Gibson & Ian Fraser

Despite its sombre colouring and diminutive stature (yes it's small and brown - see Fig 1.) Archey's frog *Leipolema archeyi*, enjoys an extraordinary celebrity status in the world of conservation. The combination of extreme evolutionary distinctiveness and global endangerment rocket this unobtrusive amphibian to the very top of the EDGE ranking. Celebrity status alone however, does little to reverse this frog's fragile predicament and Archey's frog remains a highly threatened species, confined to just two forest locations on the North Island. Decades of research *in situ* and *ex situ* have yet to reveal all that there is to know about this enigmatic little anuran and further ecological work in the field in combination with captive studies still have much to contribute to our understanding of Archey's frog.

The keeping of Archey's frogs in captivity dates back to the 1970's. Wild caught frogs have successfully produced fertile clutches of eggs and some young frogs have been produced, but a prescription for regular and reliable breeding of captive Archey's frogs has never been established.

In 2004, Auckland Zoo opened a small facility dedicated to keeping and studying Archey's frog. In 2005 it was stocked with long-term captive frogs from Canterbury University and later in 2006 received an influx of wild caught frogs. Husbandry protocols were established by the Native Frog Recovery Group, a committee of DOC staff working with the species, as well as, academic, private and zoo individuals. At this time, uncertainty concerning the threat posed by the still rather poorly understood pathogenic fungus *B. dendrobatidis* and a lack of knowledge regarding the species environmental and dietary requirements led to husbandry practices that we now know were less than ideal.



Figure 2. New outdoor Archey's frog enclosure. Photo: Auckland Zoo



Figure 1. Adult Archey's frog. Photo: Auckland Zoo

Husbandry has evolved considerably over the past half-decade in response to these issues, with every significant change being made in consultation with the Recovery Group and local Maori tribes from whose ancestral lands the frogs originate. Last year the frogs were moved from the temperature controlled indoor facility, to a purpose built outdoor facility (see Fig 2.) providing natural daily and seasonal temperature fluctuations and daylight. Their diet has also been significantly expanded with the addition of calcium-rich food items like woodlice and terrestrial amphipods and the use of a calcium-balancing supplement on all cultured insects.

In response to changes made in the past few years, the condition of the frogs has improved significantly and we have been rewarded with an increasing number of egg clutches each spring and summer. To date these have all been infertile but as this article is being written things might, just might, be taking another hop in the right direction. For several years the frogs have been maintained together in relatively large groups. More often than not, male and female Archey's frogs are physically indistinguishable. Attempts to determine the sex of frogs using hormone analysis haven't yet proved successful, so the frogs have been held in groups in the hope that both male and female frogs are present. However, since the male of the species provides parental care to the egg clutch and metamorphosing larvae, it made sense to alter the group sizes to create an even, or male biased, sex ratio wherever possible. This is common practice in breeding other frogs which demonstrate male parental care. In October this year we selected our 'best guess' males and isolated them each with a single gravid female. The dual rationale being that firstly, other frogs may interrupt the act of spawning and secondly, the male required to care for the resulting clutch may be easily distracted by other gravid females in the enclosure. Indeed, the vast majority of previous clutches had been found deserted



Figure 3. A group of Archey's frogs with deserted clutch of eggs (left). Figure 4. A male Archey's frog guarding a fresh clutch of eggs (right). Photo: Auckland Zoo

and proved infertile (see Fig 3). Two weeks after making this minor change we are happy to report two male frogs sitting on top of and guarding/caring for a clutch of eggs each, undisturbed by

other frogs (see Fig 4). Only time will tell if they are fertile, viable and will eventually result in baby Archey's frogs. Watch this space.....

Auckland Zoo staff continue to work closely with the Recovery Group and university researchers to further develop Archey's frog husbandry in order to help conserve this unique species.

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Auckland Zoo - Frog Diseases

By Stephanie Shaw

Stephanie Shaw, a veterinarian, is currently writing up her PhD thesis "Diseases of New Zealand native frogs" through James Cook University in Queensland, Australia. As part of her PhD research, Stephanie worked with the captive Archey's frog population at Auckland Zoo for 4 years while doing a concurrent clinical zoo medicine program. Alongside other clinical veterinarians, they discovered metabolic bone disease was affecting those frogs as well as the frogs in captivity at Hamilton Zoo, the University of Otago, and historically Canterbury University. Working with field biologists it was established that at least three husbandry factors were causing a problem and likely the cause for high mortality and low reproduction that has plagued these captive populations. Major changes have been instigated and captive Archey's now appear very stable with little sickness or mortality. Stephanie hopes to have the details published early next year. Stephanie's other main focus now is collating the distribution of amphibian chytrid in New Zealand and analysing those patterns in a multi-institution collaborative effort. Other papers published from her research so far on nasal parasites in captive Archey's frogs (Shaw et al. 2011) and reinfection of self-cured Archey's with amphibian chytrid (Shaw et al. 2010) can be found in the literature. Stephanie is more than happy to discuss any amphibian medicine issues with other researchers. *Author details: Stephanie Shaw, School of Public Health, Tropical Medicine and Rehabilitation Sciences, James Cook*



Stephanie monitoring the heart rate of an Archey's frog under general anesthesia using a Doppler stethoscope

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Hamilton Zoo

By Samantha Kudeweh, Mike Goold & Stephen Standley

Hochstetter's frogs *Leiopelma hochstetteri* have been held at Hamilton Zoo since 2006. We currently have 19 frogs, kept in 2 of the 4 cells in our roofed, meshed enclosure. These cells replicate a stream-bed, with ample river stones, substrate and plants providing cover and digging opportunities. A watering system is in place so that heavy natural rainfall results in a contemporaneous shower from our rainwater collection tank, replicating natural conditions as closely as we are able. Research carried out in 2010 by Emma Shaw (University of Otago), indicated that the average air and water temperatures in Hamilton Zoo's frog enclosure is very similar to the site of the source population on the Coromandel Peninsula. UVB was also very similar at both locations.

Most individuals of the colony are thought to be female and the majority of the eggs laid have been infertile. The only time that offspring hatched was in March 2010, when breeding was stimulated by the artificial rainwater system. Approximately 40 eggs were laid with 25% fertility and these were left in an artificial muddy seep in the exhibit with the adults. None of the 9 or 10 offspring progressed past the early tadpole stage.

In 2008 when x-ray monitoring was started, we found some of our frogs had metabolic bone disease (MBD). MBD in this population of Hochstetter's frog is characterised predominantly by



Figure 1. Captive bred *Leiopelma hochstetteri* tadpole 2010. Photo: Kara Goddard, Hamilton Zoo.

femoral fractures, often bilateral. Weekly treatment with calcium and vitamin D was initiated for this affected group in October 2008, and most frogs now show signs of fracture repair and normal behaviour and locomotion. No new cases of MBD have been found since the 6 monthly x-ray monitoring began. We are currently collaborating with other researchers at Auckland Zoo, James Cook University, and the University of Otago to investigate probable causes and to characterize the disease. The findings will be published early next year.

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Figure 2. Normal frog x-ray, with no obvious fractures (left). Figure 3. X-ray of frog affected by MBD - obvious fracture of the right femur, suspected hairline fracture of the left femur (middle). Figure 4. The same frog as in Fig. 3, two years later. The right femur appears to have a callus forming which may indicate healing (right). Photo: Mike Goold, Hamilton Zoo.

Massey University (Albany)

Jenny Laycock

Jenny Laycock is currently conducting her PhD research for her thesis entitled "Anthropogenic Distribution of Introduced *Litoria* Frogs and the Disease Risk to Native *Leiopelma* Frogs" and is supervised by Dianne Brunton (Massey) and Phil Bishop (University of Otago). She has started collecting data on the presence of chytrids in the pet trade and has been

surveying pet shops to determine their husbandry practices, their general amphibian knowledge and where they source their amphibians from. In addition Jenny is looking at the behavioural consequences of chytrid infection in the brown tree frog (*Litoria ewingii*).

Landcare Research (Auckland)

By Dianne Gleeson & Frank Molina

Sexing Individuals

New Zealand native Leiopelmatid frogs are monomorphic, meaning that there are no discernible physical characteristics that can reliably distinguish between males and females. This presents challenges for captive breeding, and especially for longer-term genetic management of colonies but thankfully there's a clever new non-invasive technique to sex individuals. During her PhD at Otago University, Jennifer Germano developed a reliable method to obtain urine samples from frogs in New Zealand and in conjunction with Frank Molina at Landcare Research (Auckland), established enzyme immunoassays to measure reproductive hormone metabolites. Measures of urinary estrone concentrations proved to be 98% reliable for sexing adult bell frogs, *Litoria raniformis* (Germano et al., 2009) and 94% correct as a sexing tool for monomorphic Maud Island frogs, *Leiopelma pakeka* (Germano et al., in review). The same technique has been used to sex endangered Fijian Ground Frogs, *Platymantis vitiana* (Narayan et al., 2010) and more recently Lindsay Hogan, a postdoctoral research fellow at Perth Zoo measured hormones in scat and urine to successfully sex juvenile White-bellied frogs, *Geocrinia alba*.

Taking a break from her own postdoctoral fellowship at San Diego Zoo, and as the expert "hand" for sampling frogs, Jennifer Germano is planning to come back for a stint down-under over summer. Along with Phil Bishop and Frank, plans are afoot to urine sample all 90+ captive New Zealand frogs from North to South to try and sex individuals from hormone measures. Two new species will be sexed using this technique including *L. archeyi* at Auckland Zoo and *L. hochstetteri* at Hamilton Zoo.



Jennifer Germano taking a urine sample from an 'unperturbed' Maud Island frog (*Leiopelma pakeka*). Photo: Phil Bishop.

Functional Genomics

This project is in collaboration with the University of Sydney and the University of Otago and is aimed at characterising adaptive genetic markers in order to survey populations of *Leiopelma archeyi* and *L. hochstetteri* and infer genetic diversity at functionally important loci. The candidate markers are the major histocompatibility complex (MHC) and antimicrobial peptides (AMP), both polymorphic gene families with significant roles in the vertebrate immune system.

This project is utilising Next-generation sequencing technology to sequence the transcriptome of the dorsal skin and the ventral skin of both species in order to characterise (AMPs) and to sequence the transcriptome of the spleen to characterise the MHC genes. Furthermore, we will be able to compare AMPs between the species and between the dorsal and ventral skin surfaces within species, which will help us to understand the innate immunity within the skin of these frogs, and may probably improve our marker design and development. The skin's immune defences are of course a key interest due to its potential involvement in chytridiomycosis susceptibility or resistance.

Chytrid Diagnostics

The DNA diagnostic service unit within Landcare Research, EcoGene® (www.ecogene.co.nz) is currently in the process of having an ISO/IEC 17025 accredited diagnostic test for Chytrid using Real-Time PCR. The development of this accredited test has required the establishment of a proficiency testing programme with other laboratories and sharing of validated standards. Proficiency testing partners to date include the San Diego Zoo, Pisces Molecular – Boulder Colorado, and Washington State University. Other interested parties are welcome to join.

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DNA Detects Frog Predation, University of Otago

By Bastian Egeter, Phillip J. Bishop & Bruce C. Robertson

Fossil remains indicate that the family Leiopelmatidae was once distributed in both North America and New Zealand (Feller and Hedges, 1998) but is now only represented in New Zealand by *Leiopelma* spp.. Prior to the arrival of humans (c. 800-1000 years ago), several other species of native frogs are known to have existed in New Zealand (Newman, 1996), which have since become extinct. The distributions of the four extant species; Archey's frog (*Leiopelma archeyi*), Hochstetter's frog (*L. hochstetteri*), Maud Island frog (*L. pakeka*) and Hamilton's frog (*L. hamiltoni*), have been reduced during human occupation of the country and their mainland habitats are still being lost today (Bell, 1985). Their decline has been attributed to introduced fauna (Bell, 1994), habitat fragmentation (Waldman et al., 2001), disease (Bell et al., 2004) and other poorly understood factors which have been termed "enigmatic" by Stuart *et al.* (2004), such as the effects of climate change.

Endemic species on islands are particularly vulnerable to the impacts of introduced species (Diamond and Veitch, 1981), however, the evidence to date of introduced fauna negatively impacting *Leiopelma* is largely circumstantial. Notably, the extinction of three *Leiopelma* species occurred synchronously with the advent of introduced fauna (arriving in association with human settlers), as did the range contraction of the currently extant species (Worthy 1987, Bell 1994).

We originally aimed to assess the degree to which mammalian predation may be impacting *Leiopelma* by simply kill-trapping for pest mammals (such as rats *Rattus* spp., mice *Mus musculus*, hedgehogs *Erinaceus europaeus* and Mustelids) and then inspecting their stomach and gut contents for the remains of frogs. We decided that before commencing the study it would be helpful to observe a wild ship rat (*R. rattus*) consuming a frog under laboratory conditions, and it was here we noticed a problem in our initial study design. The ship rat did indeed consume the

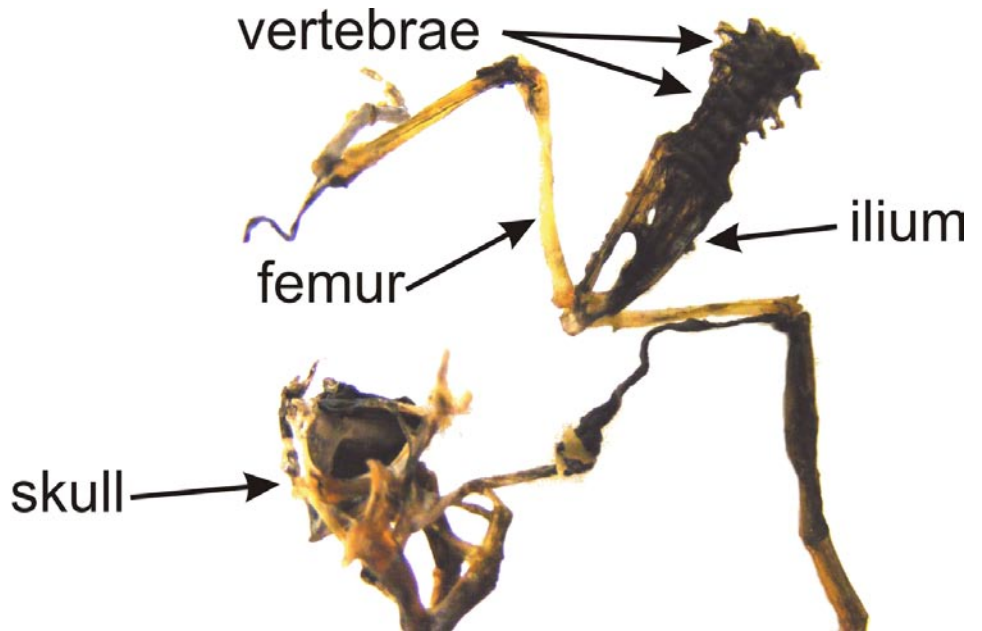


Figure 1. Frog prey remains following rat predation under laboratory conditions.

frog (in this case *Litoria raniformis*), but it meticulously and selectively consumed only the soft tissues, neglecting to ingest any skeletal components (Figure 1). Further feeding trials revealed a similar outcome for wild mice. Although hedgehogs and laboratory Norway rats (*R. norvegicus*) invariably ate entire frogs, it was often prohibitively difficult to identify the prey items from resulting stomach contents (Figure 2).

How could we reliably detect whether a small mammal trapped in the wild had recently eaten a frog, let alone determine which species of frog it had eaten?

We found the answer in DNA. Molecular analysis of predation, i.e. polymerase chain reaction (PCR) amplification of prey DNA within the faeces or digestive systems of predators, is a rapidly growing field (King et al., 2008) that is used to study trophic interactions in the field. We used specially designed primers to amplify frog DNA from mammalian stomach contents that we obtained from the laboratory feeding experiments and also from stomach samples collected within frog habitat in New Zealand. We found that the molecular method far outperformed traditional



Figure 2. Frog prey items detected in hedgehog and Norway rat stomach contents following predation under laboratory conditions. A - prey identifiable to species level (hind limbs); B - prey identifiable to order level (tarsals); C - prey unidentifiable (bone shard). The majority of stomach samples in this study contained only items comparable to C.

visual techniques, more than doubling the length of time that frog prey was detectable following ingestion, and consistently identifying prey to species level. Where visual methods failed to detect predation events in the wild, our molecular methods succeeded. The study has so far revealed that pigs (*Sus scrofa*), hedgehogs and ship rats are preying on frogs in New Zealand, including one endangered and one critically endangered frog species.

We are now taking the molecular technique a step further with the intent that it will selectively amplify DNA from *all* anuran species, but will not amplify DNA from any other species. In effect, this will enable us to analyse any predator diet sample for any frog prey item, and accurately identify the prey to species level. We have also been successful in amplifying frog prey DNA from mammalian faeces and have carried out a detailed study on the feasibility of using small mammal faeces as a non-invasive tool for anuran prey identification studies. It is hoped that the end result will be a valid ecological tool immediately applicable to any study pertaining to frog predation as well as being easily modifiable to suit other prey taxa.

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Just juice? Attempting to unravel the secrets of skin secretions in New Zealand's endemic frogs

By Sabine Melzer & Phillip J. Bishop

The four endemic species of Leiopelmatids (*L. archeyi*, *L. hamiltoni*, *L. hochstetteri* and *L. pakeka*) in New Zealand represent a unique evolutionary lineage among amphibians and are listed in the top 100 evolutionarily distinct and globally endangered amphibians (EDGE 2009). Defensive mechanisms that are displayed by all anuran species in New Zealand upon distress are posture, vocalization and the production of skin secretion (Green 1988; Williams et al. 2000). Anuran skin secretions may be compared to an arsenal of defensive weaponries, each fine-tuned to neutralise specific components of the hostile offensive system. In amphibians, the defensive content

of skin secretions is most prominently comprised of peptides and alkaloids. These compounds are synthesized, modified and stored in the granular vesicles of glands distributed across the skin. The discharge of these glands may be induced by injury or stress (Fig. 1), when a highly concentrated chemical cocktail of peptides, biogenic amines, alkaloids and proteins is released onto the skin to promote wound healing, prevent predation and kill pathogens (Barthalmus & Zielinski 1988; Rollins-Smith et al. 2011).

Our work on the morphology of *Leiopelma* skin glands provides the first report of differential skin gland dimorphism in frogs of

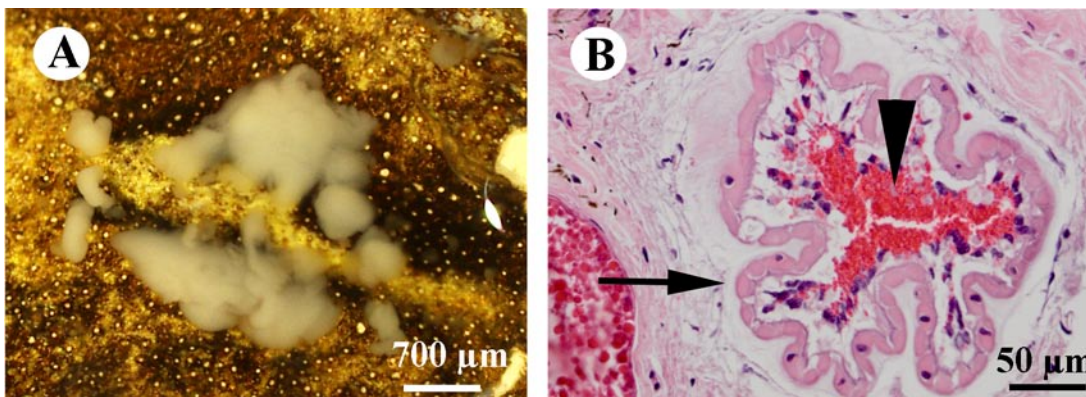


Figure 1. Bulk discharge of secretory granules after pharmacological treatment (A, B) Structural changes of type I granular gland, containing residual granules (arrowhead). Thickened smooth muscle cells causing discharge of gland content (arrow).

the same genus (Melzer et al. 2011). The differential release of secretions from type I and type II granular glands in the skin might represent an adaptation to distinct physiological or ecological needs of these species. The semi-aquatic *Leiopelma hochstetteri* may be challenged with a different suite of predators in comparison to the terrestrial *L. archeyi* and *L. pakeka*. The skin glands of endemic New

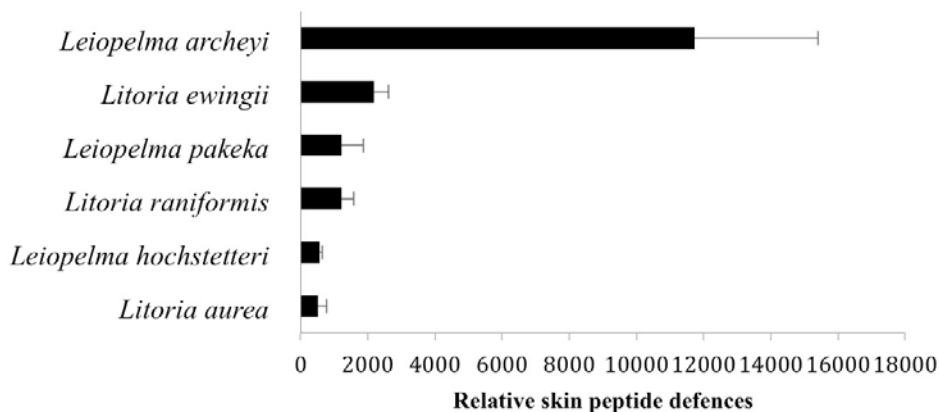


Figure 2. Relative peptide defences (\pm SE) of New Zealand frog species as calculated by multiplying the % growth inhibition of *Bd* zoospores at concentrations of 50 μ g/ml by the total amount of peptides produced per g body weight.

Zealand frogs also produce a number of previously undescribed peptides, which have protective properties (Melzer et al. 2011). The demonstration that frog skin secretions are active against disease causing agents is an important step in understanding their function. We show that both endangered endemic and naturalized anuran species in New Zealand produce skin secretions that can inhibit growth of zoospores of the amphibian chytrid (*Bd*) *in vitro* but only small amounts are secreted onto the skin when induced by mild electric stimulation (Fig. 2; Melzer & Bishop 2010). These findings are consistent with the *in vitro* activity of secretions from many other anuran species. However, there is often a discrepancy between the *in vitro* activity of skin peptides and susceptibility of amphibians to pathogens in the wild. This may well be a result of the complex interactions between pathogen, host and environment.

Not only do the secretions protect frogs from pathogens but may also provide a mechanism against predation. In New Zealand, rats and mice have been suggested as one of the main drivers for the declines and historical extinctions of native frogs. While amphibian skin secretions are often studied in the context of novel drug development, the activities of these compounds indicate they

act in defensive roles against predation in their natural context. Our work shows that an invasive rat species prefers to feed on food pellets coated in water than those covered with the skin secretions of the endemic frog *Leiopelma pakeka* (Melzer et al. under review). Skin peptides of this species can also rupture red blood cells of rats. Our findings indicate that rats may avoid feeding on native frogs, although feeding patterns in the wild (where food is scarce) need to be investigated.

With the accelerating rate of amphibian extinctions, the fascinating secrets of glandular defence in many amphibian species will regrettably remain undiscovered. However, as the number of

non-invasive tools to study amphibians is constantly increasing with the advance and development of new technologies, there is much reason to be optimistic about the possibility of gently unravelling some of the secrets that have been kept for millions of years by the archaic *Leiopelma* species.

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Susceptibility to chytridiomycosis

By Michel Ohmer & Phillip J. Bishop

Chytridiomycosis, the amphibian disease caused by the pathogen *Batrachochytrium dendrobatidis* (*Bd*), has been considered a threat to New Zealand's native frogs since its discovery by Waldman et al. (2001) in 1999. In order to better assess the magnitude of this threat, Masters student Michel Ohmer investigated the susceptibility of our native species to this disease. She has determined that two of New Zealand's four endemic frog species, *Leiopelma pakeka* and *L. hochstetteri*, demonstrate low susceptibility to infection with *Bd*. A New Zealand isolate of *Bd* was used to infect individuals of each species, and their infection status was monitored over time using quantitative PCR. Experimental infection trials revealed that both species could become infected with *Bd* at



Leiopelma pakeka. Photo: Michel Ohmer.

low levels, but completely cleared infection within 10-15 weeks by themselves. These results align with previous research that a third leiopelmatid frog, *L. archeyi*, can also clear *Bd* infection in the laboratory (Bishop et al., 2009; Shaw et al., 2010), indicating a genus-wide trend. Michel's work provides reassurance that the risk of chytridiomycosis in captive populations of *Leiopelma* species is low. However, care needs to be taken when extrapolating these results to wild populations, given that many biotic and abiotic factors can influence susceptibility to disease in the wild.

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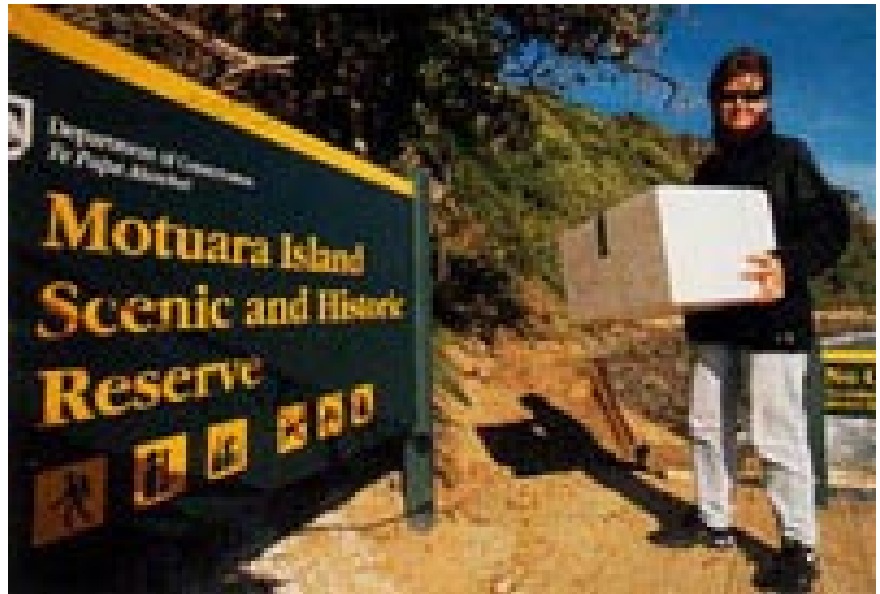
'State of the nation' report on New Zealand translocations including a quick overview of past translocations

By Mandy Tocher

The first documented wild-wild translocation of New Zealand *Leiopelma* spp. was carried out by Dr Ben Bell in 1984, in association with New Zealand's Department of Conservation. One hundred Maud Island frogs *Leiopelma pakeka* were translocated from the main forest remnant of Maud Island, Marlborough Sounds, to another forested site on the island (Bell et al. 2004). Seventy per cent of the translocated frogs were recovered after 20-years of follow-up monitoring and the new population is now considered well established.

A second translocation was attempted in 1992 when twelve Stephens Island frogs (*L. hamiltoni*) were translocated from the "frog bank" on Stephens Island, to a man-made frog-pit 70 m away (Brown 1994). Although several frogs returned to their original site (Tocher & Brown 2004), at least one breeding event occurred (a juvenile was found in 1996). No other evidence of breeding has been noted since, despite regular searches occurring at the frog pit. Natural colonisation of the frog-pit by frogs spreading from the frog bank is unlikely due to high densities of the predatory tuatara (*Sphenodon punctatus*) resident in the area between the two frog habitats. Stephens Island (and Maud Island) are maintained "introduced mammalian predator-free" by DOC.

The Maud Island frog (*Leiopelma pakeka*) has also been the subject of at least one successful inter-island translocation. In May 1997, 300 *L. pakeka* were translocated from Maud Island to predator-free Motuara Island (Tocher & Newman 1997, Tocher & Pledger 2005). By August 2002, 155 of the translocated frogs had been recaptured and the population contained a range of young to older frogs; population estimates indicated the population on Motuara Island had stabilised with losses of the translocated frogs offset by new recruits. The first juvenile frog was found in January 1998, only 10 months after the translocation and 42 recruits were captured by August 2002 (Tocher & Pledger 2005). The Motuara



Mandy Tocher with frogs for release onto Motuara Island. Photo: Dave Houston, Department of Conservation, New Zealand.

population continues to thrive and monitoring is now reduced to infrequent checks as resources permit.

A second inter-island translocation of *L. pakeka* was carried out in 2006. Here 101 frogs were translocated from Maud Island to Long Island (Germano and Bishop, in prep.). The fate of this population remains unknown but given the success of other translocations involving *L. pakeka*, the Long Island population is likely to be slowly establishing. No further monitoring is planned for this population.

The first inter-island translocation of *L. hamiltoni* was carried out between May 2004 and July 2006 by the Department of Conservation. Seventy one frogs were translocated from the frog bank on Stephens Island to Nukuwaiata Island. Given the rarity of this frog a cautious approach was taken when selecting the number and age of the frogs to be translocated. A stage-structured population model was developed to predict

which of nine hypothetical translocation scenarios was likely to produce the best outcome for this rare *Leiopelma* species (Tocher et al. 2006). Model outcome was measured in terms of population growth rate and probability of extinction of both the donor population (Stephens Island) and the new population on Nukuwaiata Island (Tocher et al. 2006). Post release monitoring by the DOC is on-going for both of these *L. hamiltoni* populations. The establishment of *L. hamiltoni* on Nukuwaiata was much slower than that shown for translocations involving *L. pakeka*; in particular the production of juveniles was worryingly slow on Nukuwaiata and similarly the Stephens Island population did not rebound as quickly as we had hoped. Results from an August 2011 monitoring trip indicate both populations are now doing very well; for Nukuwaiata repeated breeding has occurred and new recruits are almost at breeding age. We expect to declare the translocation a success within two years. There is no evidence of declines on Stephens Island; the population there appears healthy and is now rebounding well following the heavy cropping it underwent for translocation to Nukuwaiata Island.

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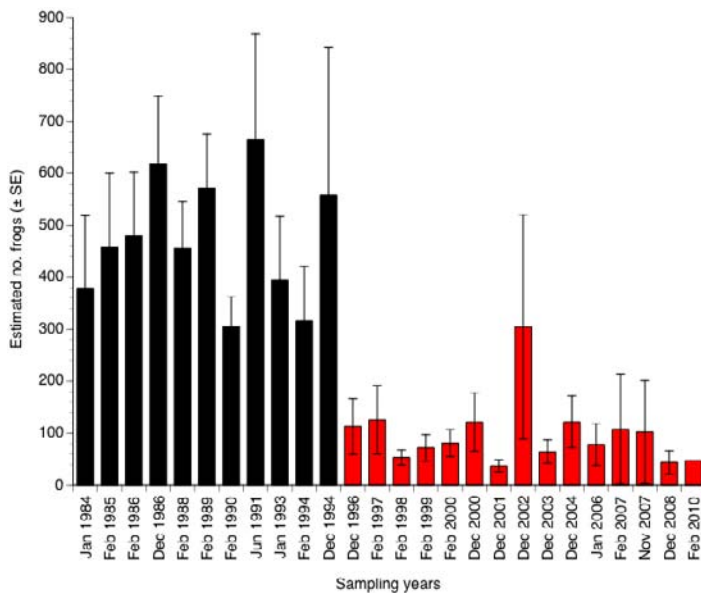
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Long term population monitoring of the Maud Island frog and Archey's frog, Victoria University of Wellington

By Ben D. Bell

On Maud Island regular (annual) monitoring of *Leiopelma pakeka* continues. On the last sampling visit during the period 8-15 March 2010, 206 captures of 163 individuals were made at three long-term study sites, including 37 new individuals, most of them (34) at Boat Bay, a site to which 100 frogs were translocated in 1984-85 (Bell, Pledger & Dewhurst 2004). Ventral skin swabs were taken from 88 animals for future assessment of their chytrid fungus (*Batrachochytrium*



Jolly-Seber population estimates of population size of *L. archeyi* on the Tapu Ridge study plot, 1983-2010. Error bars = 1 SE.

dendrobatidis) status. We conclude that the translocation to Boat Bay has been a success and that the population is now well established there. A recent analysis of population trends on two long-term study plots (Bell & Pledger 2010) showed that over the last 15 sampling sessions a linear decline was evident. In 2010 we also assessed patterns of eye venation as a method for individual identification, particularly useful for darker frogs lacking individually distinctive body patterning. No sick, dead or dying frogs were found. In the Zealandia sanctuary, Wellington, *L. pakeka* continues to do well in protected enclosures, although out of the enclosures they appear prone to predation, probably from house mice and possibly birds (Bell, Bishop & Germano 2010). The frogs have successfully bred in the Zealandia enclosures for four successive years, progeny now being reared in protected nursery enclosures. In October 2011 a limited number of adults were moved to a new enclosure allowing them to be observed by the general public on escorted night tours of the sanctuary.

Long term population studies also continue on *L. archeyi*, the smallest of the indigenous New Zealand species (<38 mm), restricted to two regions on the mainland North Island, the Coromandel Peninsula and the Whareorino Forest, west of Te Kuiti. In both of these areas it occurs sympatrically with *L. hochstetteri*. It ranks as the No. 1 amphibian species on the EDGE List. They prefer to live at a relatively high altitude from about 400-1000m in moist native forest. They are terrestrial and nocturnal, spending most of the day hidden under stones or logs away from streams or creeks. Like *L. pakeka* and *L. hamiltoni*, *L. archeyi* are terrestrial breeders, laying a small clutch of eggs in a moist site under stones or logs. They exhibit parental care with

the tailed froglets remaining on their father's back for several weeks until metamorphosis is nearly complete. They have been successfully bred in captivity (Bell 1985, 2010; Thurley & Bell 1995). *L. archeyi* populations decreased by up to 88% from the mid-1990s (Bell et al. 2004). Several factors including the severity and rapidity of the population crash, the geographic spread of the decline (from south to north), and the discovery of frogs with chytridiomycosis (caused by *Batrachochytrium dendrobatidis*) all point to disease being the major cause of the decline. Annual sampling of the population continues in the Coromandel ranges to estimate numbers and rates of chytrid infection at a long-term study site. Low levels of recruitment continue, but numbers have not recovered substantially since the main decline.

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Brief Encounters with Archey's Frog

By Bruce Waldman

New Zealand frogs (Leiopelmatidae) are “living fossils” that have changed little over perhaps 200 million years. Their world, until the arrival of humans, was dominated by birds rather than mammals. Now they exist only in limited tracts of native bush in the North Island and Marlborough Sounds. So with great anticipation, in 1992 I first ventured to the Coromandel Peninsula in search of Archey's frogs (*Leiopelma archeyi*), one of four described extant native species (but see Holyoake et al. 2001 for further discussion).

Archey's frogs move slowly, seemingly deliberately, generally are silent, and their round eyes do not reflect light, so at first I couldn't find any. Then I saw one perched on short vegetation, then another, and another, and having developed a search image I suddenly realized that they had been all around me the entire time (Figure 1). Indeed, the frogs were so abundant that I couldn't count them all. Later we would find that *Leiopelma* frogs communicate among one another with scents rather than sounds (Lee and Waldman 2002, Waldman and Bishop 2004).

I was surprised to find Archey's frogs not only on mountain tops but also in regenerating bush near sea level. However, in subsequent years, the frogs became progressively more difficult to find, first disappearing totally from lowland habitat. Beginning in 1995, finding frogs required exhaustive searching, not just in the vegetation at night, but also under rocks in which the same individuals had been repeatedly seen for up to 23 years (Bell et al. 2004).

Initial discovery of chytrid fungus in New Zealand

In 1999, about 1000 km south in Canterbury, on the South Island, I witnessed the first frogs showing clinical signs of chytridiomycosis in New Zealand. Southern bell frogs (*Litoria raniformis*) swam erratically in a pond at Godley Head. Many struggled to leave the pond, showing seizures and partial paralysis (Figure 2). With Richard Norman, we identified



Figure 1. Archey's frog foraging at night in the Coromandel Peninsula. Photo: Bruce Waldman.

Batrachochytrium dendrobatidis (*Bd*) zoospores in the skin of sick frogs and carcasses (Waldman et al. 2001). The epizootic appeared short-lived among adults, but metamorphosing froglets died in large numbers.

I knew this pond to be a major source of frogs for the pet trade, so I attempted, unsuccessfully, to seek legal action to cordon off the pond and to halt trade in frogs. During the following months, we documented that *Bd* had spread throughout and possibly beyond Canterbury. Few frogs returned to the pond over the next few years. But by 2006 the population started to recover and in 2011 I observed no mortality among metamorphs.



Figure 2. Left: Southern bell frog, infected by chytrid fungus, struggling to leave a pond in November 1999. Right: Sign warning people not to collect frogs from this pond. Photos: Bruce Waldman.

While *Litoria raniformis* and its close relative *L. aurea* are threatened or endangered in their native Australia, many consider them pests in New Zealand where the species remain unprotected and populations persist. I feared that *Litoria* frogs sold as pets would be released into areas of the North Island inhabited by *Leiopelma* frogs and spread *Bd* to them.

Witnessing Archey's frogs dying in the field

At the University of Canterbury (UC), with the assistance of Richard Norman, I set up a histology laboratory to diagnose *Bd* and soon thereafter, my student Ermin Šadic and I devised a sensitive PCR test for *Bd*. Until 2005, this facility served as the primary New Zealand center for *Bd* diagnoses. We found the incidence of *Bd* infection to range between 30 and 37% in the three introduced *Litoria* species, but barely above 0% in Archey's frogs (Šadic and Waldman 2004). Archey's frogs are fully terrestrial, breeding on land, so infection would require exposure to high concentrations of *Bd* zoospores in soil.

Yet, Archey's frogs continued to disappear from Coromandel populations. In 2001 and 2002, I felt fortunate to find even a single frog during my nighttime searches. Even then, the frogs that I found appeared unhealthy, bearing skin ulcerations or blisters that I had never seen before (Figure 3). Not infrequently, I found carcasses. Frustrated by the Department of Conservation's (DOC) slow response, I engaged the media to warn of the frogs'

imminent demise. *New Scientist* called for urgent action to save Archey's frog: "New Zealand has a fine record of conserving endangered species such as the kakapo, the flightless parrot that is intensively monitored. It's time to lavish similar attention on the nation's amphibians. They may not be as cute as the kakapo, but they are no less important" (Editorial 2002).

Sick frogs recover and successful breeding

My efforts were successful and I obtained support and funding to maintain an *ex situ* population

of Archey's frogs. Forty-nine Archey's frogs were delivered to a new purpose-built facility at UC, accompanied by Māori tribal elders. For months, my students and I monitored the frogs carefully for any signs of disease. Once confident that they were safe, we released the frogs into tanks simulating their natural environment, where they began to breed within weeks (Figure 4).

Meanwhile, in my laboratory, we recorded the disease progression of sick Archey's frogs that I found in the field, as agreed by DOC. None of the sick frogs showed clinical signs of chytridiomycosis and all tested negative for *Bd* infection. Although some individuals subsequently succumbed to disease, many others recovered. Skin ulcerations healed and many blisters disappeared without pharmacological intervention.

Tests were needed urgently to determine the susceptibility of Archey's frogs to *Bd*. I contracted with DOC to conduct these tests, first perfecting our techniques on introduced bell frogs (Carver et al. 2010). However, in the intervening few months, Archey's frog populations continued to dramatically decline and I no longer could find frogs in the field. I feared that the frogs that I had collected earlier for the infection experiment might be the last surviving Coromandel Archey's frogs. I was not willing to put these animals at risk by infecting them with *Bd*.

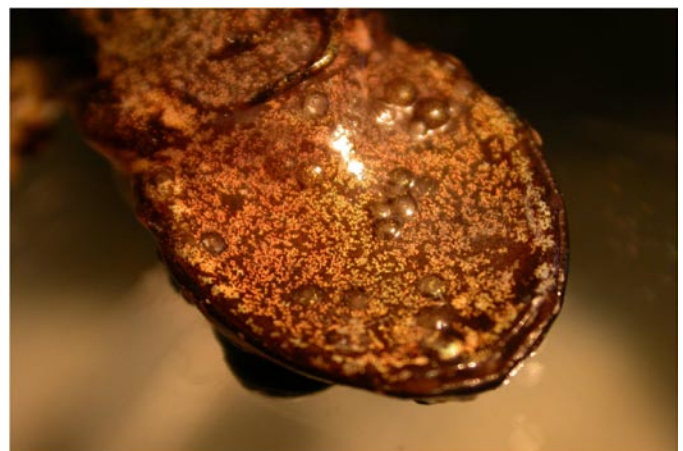


Figure 3. Left: Denuded ventral skin, heavily infiltrated by bacteria. Right: Blisters under lower jaw. Photos: Matt Walters.



Figure 4. Left: Archey's tadpole, reared in our laboratory on moist filter paper. Photo: Matt Walters. Right: After metamorphosis, the same froglet on its parent's back, held in the author's hand. Photo: Martin Hunter.

So why are Archey's frogs dying?

Our necropsies suggested that dying frogs suffered from a variety of diseases. I suspected that something in the environment, possibly pesticides or poisons such as those used to kill introduced mammals, was causing sublethal stress on the frogs that compromised their immune systems. This, in turn, might make them vulnerable to pathogens, possibly including chytrid fungus but also bacteria, viruses and other fungi that normally would pose no risk to them. I feared that the species was in danger of imminent extinction, so when approached by a reporter, I discussed my concerns (Ross 2005). Soon thereafter, DOC halted research at my UC laboratory and the Archey's frog colony was transferred to Auckland Zoo.

Four years later, over half of the colony had died, including offspring bred at UC, and the frogs have not successfully bred again in captivity (Gibson 2009). We had been making good progress on several lines of investigation into why the frogs were dying, but neither my collaborators nor I were able to complete these studies. Other researchers continued some aspects of the work that we started. Why the frogs are dying in the wild remains a mystery.

Conclusion

Saving a species requires detailed knowledge and appreciation of the organism's biology, solid scientific research, and meaningful collaboration among researchers, governmental departments, zoos, and the public. Further studies are needed to determine whether frogs remaining in the field suffer from immunosuppression, and if so, to identify the factors that are making them susceptible to disease. We share a responsibility to save Archey's frog, ranked the most evolutionarily distinct amphibian in the world, from extinction.

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New Beginnings — A First Report on Frog Research in Timor-Leste

By Hinrich Kaiser, Zito Afranio Soares & Mark O'Shea

As Southeast Asia's newest nation (independence was achieved only in 2002), Timor-Leste is the last of the countries in the region to begin developing biological research and environmental management programs. With a geographic position at the presumed intersection of Southeast Asian and Australo-Papuan faunal elements, it may also be one of the most interesting places to study.

Given its 500-year colonial history and a location just a few hundred miles off the north coast of Australia, we were astonished to learn when we began our investigations in Timor-Leste that the extent of frog research on Timor Island as a whole, and the area of the sovereign nation Timor-Leste in particular, was essentially nil. Very limited frog material was collected by intermittent expeditions to Indonesian West Timor, most notable among them those made by Malcolm Smith from the British Museum (Smith 1927). Based on a thorough survey of museum collections worldwide in 2010, the only catalogued frog specimens from the area of what is now Timor-Leste we could locate are housed in the collections at the University of Papua New Guinea, representing fieldwork by James Menzies in the mid-1980s (see Menzies 1987 for an account). Small collections made by Colin Trainor (Charles Darwin University) and Stephen Richards (South Australian Museum) have been deposited in Australian institutions and will be accessioned shortly. As part of our comprehensive amphibian and reptile survey of Timor-Leste (Kaiser et al. 2011), we have assembled a collection of frogs from many localities in all 13 districts, which is housed in the U.S. National Museum of Natural History, Smithsonian Institution, Washington, D.C. As a consequence of the dearth of specimens from Timor-Leste, it will be impossible to conduct the types of historical analyses that

have been used to trace chytrid infections in many of the world's regions.

The diversity of the frog fauna in Timor-Leste is currently limited to five confirmed species (*Duttaphrynus melanostictus*, *Fejervarya verruculosa*, *Limnonectes timorensis*, *Litoria everetti*, *Polypedates leucomystax*) and the unconfirmed *Litoria infrafrenata*. However, our recent fieldwork indicates that this list underestimates the true diversity of *Fejervarya* and *Polypedates*, and analyses are ongoing. Recent preliminary work by ZSA shows that there is a significant effect of habitat moisture on the diversity and distribution of frogs at medium elevations (200–700 m) near Maliana, Bobonaro District (Afranio Soares 2011), with the invasive toads comprising a lesser component of the fauna at sites with higher moisture and at less disturbed sites. For a first glance at key species for conservation concern in Timor-Leste we wish to single out the only confirmed single-island endemic, *Limnonectes timorensis*, and the recently introduced toad *Duttaphrynus melanostictus*.

Limnonectes timorensis (Smith 1927)

The Timor river frog (Fig. 1) is a species apparently restricted to habitats in the immediate proximity of rivers and streams. It appears to be patchily distributed, though it seems to be relatively common where it occurs. Smith (1927) found the specimens of his type series in Djamplong (elev. ca. 200 m) and Soë (elev. ca. 800 m) in West Timor, whereas our specimens come from a single site near Eraulo, Ermera District, Timor-Leste (elev. ca. 1200 m). Our site is a streambed of width varying between 5–25 m with seasonally divergent water levels. Frogs were seen active by night among the rocks in the center of the streambed, and hiding by day

along the decaying foliage and rocky debris at the stream's edge. There appears to be sexual size and color dimorphism, with females 50% larger than males, and with males having a darker overall ventral coloration. Based on the differences in altitude between these sites, the species displays a distinctive cold tolerance. As the only single-island endemic frog on Timor Island, *L. timorensis* is of considerable interest both from a conservation standpoint and for biogeographic reasons.

Duttaphrynus melanostictus (Schneider 1799)

The common Asian toad (Fig. 2) was introduced into Timor-Leste fairly recently, probably during the staging of the international peacekeeping force in the transition period from Indonesian occupation to independence (1999–2002). During this time, migration of a considerable number of people between West Timor and Timor-Leste also took place, which may have sped up the inadvertent



Fig. 1. Adult male individual Timor river frog (*Limnonectes timorensis*) from the Meleotegi River near Eraulo, Ermera District, Timor-Leste (elevation 1225 m). Several individuals were discovered under flat rocks in the muddy interface between land and water at the edge of the river. Photo: Mark O'Shea.

spread of toads (see Trainor 2009 for a more detailed account of the species' presumed origin). Two recent reports (Kaiser et al. 2011, Trainor 2009) detail the expansion of the species and its misidentification as the invasive Australian toad, *Rhinella marina*. Breeding populations of *D. melanostictus* are currently known to occur in the Oecusse exclave at the western extreme of Timor-Leste, and in the contiguous districts of the country to at least east of the town of Manatuto, Manatuto District on the north coast and the village of Uma Boot, Viqueque District on the south coast, covering over half the country's area. Our surveys have revealed no toads in Lautém District (far eastern Timor-Leste in the area of the towns of Com, Lospalos, Iliomar, and Tutuala, and near Loré village). It appears that the distribution of the species is relatively patchy, indicating that its most likely mode of transportation is via the agency of humans. We have seen the species in all manner of anthropogenic areas, ranging from towns to rice paddies and coffee forest, and in roadside ditches along most roads. Monitoring of the further expansion of the species, as well as its predicted impact on populations of other animals, is a conservation priority.

Acknowledgments

Our initial foray into the frog world of Timor-Leste would not have been possible without the expressed permission and support of His Excellency, Prime Minister Xanana Gusmão. His Senior Adviser Claudia Abate-Debat was incredibly effective in opening doors for high-level discussions and tireless in working to ascertain logistical support. Our fieldwork benefited particularly from groups of highly motivated students, including Scott Heacox, Eric Leatham, Caitlin Sanchez, and David Taylor from Victor Valley College, and Luis Lemos and Agivedo "Laca" Ribeiro from the Universidade Nacional de Timor Lorosa'e. Collecting permits were kindly provided by Manuel Mendes, Director of National Parks, Ministry of Agriculture and Fisheries. Financial assistance was provided by the Associated Student Body at Victor Valley College and the Victor Valley College Foundation. This article is Contribution No. 8 from the Tropical Research Initiative at Victor Valley College.

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Fig. 2. Amplexing pair of the common Asian toad (*Duttaphrynus melanostictus*) from near Maliana, Bobonaro District, Timor-Leste (elevation 197 m). Photo: Zito Afranio Soares.

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SAVE THE FROGS! Ghana Powering Africa's Environmental Revolution

By Gilbert B. Adum

Amphibians have been rapidly disappearing in Ghana, the rest of Africa and worldwide. For the last two decades these declines have littered the scientific literature and dominated roundtable discussions at scientific conferences. But there remains a missing link that could be a powerful revolutionary tool in reversing the trend of declining amphibians – building community-driven grassroots organizations dedicated exclusively to amphibian conservation. SAVE THE FROGS! Ghana (www.savethefrogs.com/ghana) is such an initiative that has been launched in the West Africa country of Ghana to protect amphibian life threatened by extinction. SAVE THE FROGS! Ghana is an offshoot of USA-based non-profit organization SAVE THE FROGS!.

SAVE THE FROGS! Founder Dr. Kerry Kriger travelled to Ghana in September 2011 to implement amphibian conservation programs in the country. Upon my initial meeting with Dr. Kriger, it quickly became clear that there was a huge need for a SAVE THE FROGS! branch in Ghana and that the timing was perfect for forming the new organization. Within a week, SAVE THE FROGS! Ghana was officially announced, a Board formed, a plan of action devised and a new era of amphibian conservation in Africa had arisen.

SAVE THE FROGS! Ghana's first line of action is creating the Atewa Hills National Park, which would be Ghana's 6th national park. Atewa Hills is the final remaining home of the critically endangered Togo Slippery Frog (*Conraua derooi*), which lives on two streams in the Atewa Hills and nowhere else. *Conraua derooi* is the closest relative of the world's largest frog, the Goliath Giant Frog (*Conraua goliath*). The Atewa Hills also supports exceptional numbers of endemic and rare flora and fauna

including black star plant species and 700+ butterfly species. Unfortunately, the reserve is under constant threat from mining interests and illegal logging, and is not managed as a wildlife reserve. Locals also exploit the Togo Slippery Frog for food consumption. Therefore, preserving the reserve as a National Park would afford it the fullest protection deserved, and would prevent its becoming another mountaintop removal site that once harboured abundant wildlife, as has unfortunately been the case elsewhere in West Africa.

As the Atewa Hills harbour the highest biodiversity in Ghana, one would assume its conversion to a national park would be fairly simple. However, many influential companies and individuals profit off of the continued exploitation of the Atewa Hills and are working diligently to thwart any efforts of turning it into a national park. Our goal therefore is to educate the surrounding villages about the importance of the Atewa Hills to their livelihoods; to build nationwide and international movements to protect the Atewa Hills, and to educate our country's politicians and other decision-makers about the value in permanently protecting the reserve as the Atewa Hills National Park. We are also developing paper petitions that will be distributed at schools and universities throughout Ghana, and electronic petitions that will gather signatures from citizens around the world. You can learn more about the Atewa Hills and our campaign, and sign the petition, at: www.savethefrogs.com/atewa.



“Africa does not need strong men, it needs strong institutions.” This was President Barack Obama's advice to Africans when he was last in Ghana in 2009. As far as amphibian conservation is concerned there are few African institutions that are equipped with the necessary resources including the capacity to train their people to conserve amphibians. In Ghana for instance there are only two professional amphibian biologists, myself and Caleb Ofori Boateng, both trained by Mark-Oliver Rödel of Humboldt University, Germany. This lack of amphibian biologists presents a clear problem, so SAVE THE FROGS! Ghana is working to increase the number of amphibian biologists 5-fold within a decade. We have already initiated a SAVE THE FROGS! Ghana chapter at the country's leading science university (see www.savethefrogs.com/knust), and these undergraduates will be spreading amphibian education and awareness to primary schools in their catchment areas. Already there about 300 volunteers, including students from the Kwame Nkrumah University of Science and Technology and scientists from the Forest Research Institute of Ghana. These members are extremely enthusiastic and we are confident the new initiative will make a positive impact.

In turn, we are stimulating and sustaining their interests in frog research and conservation by enhancing their capacities in the taxonomy, ecology and importance of frogs. With the assistance of SAVE THE FROGS! in the USA, we are making small



The critically endangered Togo Slippery Frog (*Conraua deroo*) Photo: Caleb Ofori

grants available to undergraduate students so that they can pursue amphibian research projects, supervised by and of interest to myself and Caleb, Ghana's other amphibian biologists. For the general public we have embarked on awareness campaigns in churches and schools, and through radio broadcasts. We are planning to implement alternative livelihood activities such as beekeeping and mushroom farming in communities that currently eat frogs or destroy their habitats.

We have also been drumming for the Ghanaian frogs and for that reason we have on our board a music celebrity, who is a Big Brother Africa Star, Mimi. We are planning a large benefit concert on the 4th Annual Save The Frogs Day, April 28th 2012 (www.savethefrogs.com/day). Soccer is huge in Ghana, so we are also funding SAVE THE FROGS! Ghana soccer teams in communities surrounding critical frog habitats.

Ghana has been the hope of the African continent since the dawn of colonization, as emblemized by the black star on the nation's flag. We hope SAVE THE FROGS! Ghana will serve as a model and as inspiration for amphibian conservationists throughout the African continent and the world at large. SAVE THE FROGS! Ghana is a nonprofit organization in a developing country though, and as Dr. Kriger states: "the difference between success and failure in saving Ghana's frogs will come down to how much support the outside world provides." SAVE THE FROGS! Ghana appreciates your advice, and your financial support! Please go to www.savethefrogs.com/ghana for more information.

ACKNOWLEDGEMENT

We thank Mark-Oliver Rödel of Humboldt University, Germany, for having supported so many conservation activities in West Africa. We also thank all SAVE THE FROGS! donors around the world, without whom SAVE THE FROGS! Ghana would not exist. We acknowledge the support of our Board of Directors and all our members.

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The beginning of a career and the value of mentoring young scientists

By Scott Boisvert

My adventures began in 2007 when I was selected as the Jr. High Grand Award winner at the Arizona Science and Engineering Fair, and so attended the Intel International Science & Engineering Fair (ISEF) as an observer. Being at ISEF really inspired me to do a great research project so I could go back the following year, this time to compete. So I began to network with a plan of finding someone willing to open their lab to a high school freshman. I had the tremendous opportunity to meet Dr. Elizabeth Davidson of Arizona State University who became my mentor for the next three years. At

our first meeting she described the work being done for amphibians because of global population decline, and reviewed the history with *Batrachochytrium dendrobatidis*. This brought to mind growing up in Michigan, spending many afternoons sitting along a creek near my house watching and trying to catch frogs. When I thought about amphibians facing a real threat of mass extinction, I couldn't accept the idea that one day my children or grandchildren may not be able to enjoy the same experiences. I was inspired to find something that could help, and that moment confirmed my interest in this research.



Scott Boisvert with mentor Dr. Elizabeth Davidson, Research Professor in Life Sciences at Arizona State University.



Conducting fieldwork with Glenn Frederick, of the US Dept. of Agriculture Forest Service, and Oliver Hyman of Arizona State University.

My research evaluated how an amphibian's aquatic environment influences the growth and chemotaxis of *B. dendrobatidis*. Water samples collected from amphibian habitats across Arizona were analyzed to describe the inorganic water chemistry for each habitat; samples represented diverse geographic conditions which impact the water chemistry of a site. Bioassay experimentation documented the fungus' growth within each water sample. A modified two-chamber assay was developed to measure the chemotactic response of *B. dendrobatidis*, and a novel method was developed to cultivate the microorganism using custom agars incorporating the water samples to reflect environmental effects on the fungus. Ion Chromatography and Ion-Coupled Plasma Spectrometry documented the water chemistry. Statistical analyses isolated the factors significant to *B. dendrobatidis* growth and chemotaxis, identifying elements as inhibitors or facilitators. This work demonstrated that the aquatic environment affects *B. dendrobatidis* as growth and chemotaxis varied dependent upon the water chemistry of the site, and geographic trends were observed. This study may serve as a useful guide in conservation efforts, interpreting how a habitat's water chemistry may protect or predispose amphibians to infection from *B. dendrobatidis* through effects on the pathogen's growth and potential infectivity. I hope the results may be put

directly into practice; for example, to set up and maintain proper water chemistry in exhibits or captive breeding programs in order to inhibit *B. dendrobatidis* and reduce infection within their populations. Also, used as a guide to identify field sites having water chemistry that naturally inhibits growth, as these sites can be considered safe-havens for amphibian re-introduction programs. Conversely, it can monitor field sites for water chemistry that facilitates the fungus, identifying habitats that place amphibians at increased risk of disease so they may be relocated.

I am very grateful to my mentor for giving a kid a chance in the lab which opened the door to the many experiences that this project provided. I have learned so many techniques and thought processes for carrying out successful science research. More importantly, this project has led to numerous other opportunities, each one providing new and deeper learning. In addition to my own field work collecting water samples, I had the opportunity to spend the day with Glenn Frederick, Wildlife Biologist for the Coronado National Forest, and Oliver Hyman of Arizona State University, to observe testing methods for confirming amphibian infection with *Bd*; as well as work with Dan Groebner, Nongame Specialist with the Arizona Game & Fish Department, toward implementing my research into his programs. I have delivered

my work at numerous science fairs and in many different forms, written reports, oral defenses, multi-media presentations; all of which have strengthened my abilities to communicate science which I have come to realize is often as important as conducting the work itself. This led to a published article in the *Journal of Wildlife Diseases*, a conference presentation at the Joint Annual Meeting of the Arizona/New Mexico Chapters of the American Fisheries Society and the Wildlife Society, and a poster presentation at the 2009 Annual Water Environment Federation Technical Exhibition & Conference. I explored science fields as a delegate to the National Youth Science Camp and the National Youth Leadership Forum on Medicine. I also developed new lab skills and affirmed my interests in research through an internship

at The Translational Genomics Research Institute studying drug resistance in non-small cell lung cancer. I was fortunate to be honored for the research I conducted being selected as a 2010 Davidson Fellow, a 2011 Intel Science Talent Search Top 10 winner, as well as many other awards and scholarships.

The inspiring experiences that I have had while conducting my project have given me the necessary background and assured me that I want to do science. I am presently a freshman at Duke University studying Molecular & Cellular Biology and Global Health as a Robertson Scholar. I have no doubt that the opportunities I received in high school because of my involvement in science research paved the way for my present success. My career path is to obtain an MD/PhD degree to combine my interests in medicine with my passion for research. My background working with amphibians established my interest in infectious disease processes, and I am now working to set up an independent study at the Duke Human Vaccine Institute beginning next semester. Not only has my work with amphibians set my path, but it has sharpened my appreciation for the natural world around me and the cause for biodiversity.

Recent Publications

Conservation and Ecology

Choosing the survivors? A GIS-based triage support tool for micro-endemics: application to data for Mexican amphibians

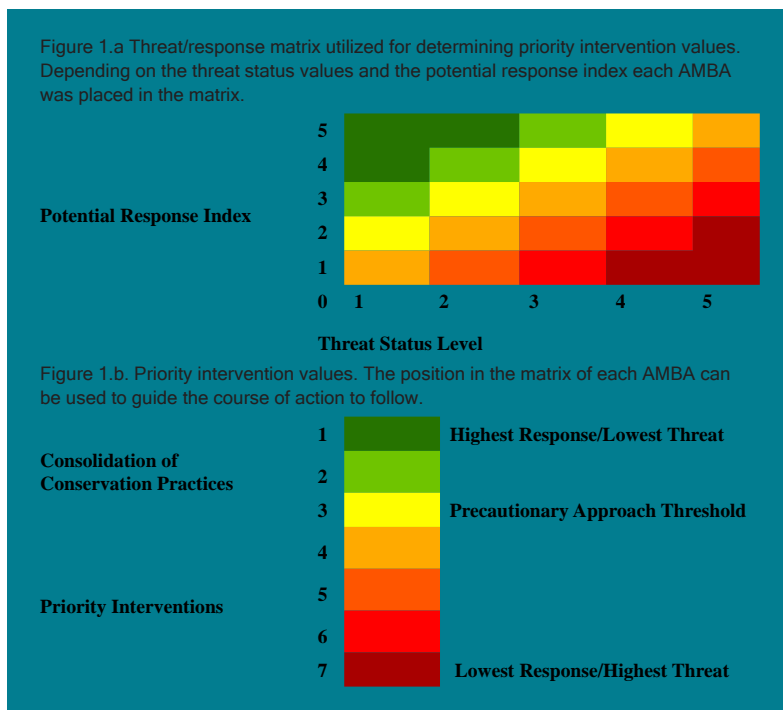
By Leticia M. Ochoa-Ochoa, Juan E. Bezaury-Creel, Luis-Bernardo Vázquez, & Oscar Flores-Villela.

Given the current speed of land use change, a question is looming ever closer. Will it be possible to conserve everything? Or limited financial resources will constrain our efforts to just a subset

(AMBAs) in order to evaluate threats and the potential abatement response. To prioritize the AMBAs we used existing and newly compiled spatial databases of territorial conservation instruments, threats, and amphibian range distributions for Mexico. We identify 50% of Mexican micro-endemic amphibians as requiring urgent actions. Based on the location of the AMBAs, using the different conservation instruments existing in Mexico, it was possible to recommend a conservation strategy for the majority of these species. However, almost 25% urgently need field-base verification to confirm their persistence due to the small percentage of remnant natural vegetation

justify further conservation investment and where *ex-situ* strategies could be considered as better options (Figure 1).

Full article: Ochoa-Ochoa, L.M., Bezaury-Creel, J.E., Vázquez, L.-B. & Flores-Villela, O. Choosing the survivors? A GIS-based triage support tool for micro-endemics: Application to data for Mexican amphibians. *Biological Conservation*, 144, 2710-2718.



of species? Are we explicitly condemning species to extinction? Or through the application of the maxim “choose the battles that you can win”, should we focus our strategies and prevent the greatest number of species extinctions through the use of conservation triaging tools? Our paper (Ochoa-Ochoa et al., 2011) proposes a simple conservation triage method that evaluates the threat status of different species, assesses current potential threat abatement responses derived from existing policy instruments and social initiatives; and combines both indicators to provide broad-scale indicators of conservation strategies that would best suit each place for conservation. The example presented in Ochoa-Ochoa et al. (2011) is focused on micro-endemic Mexican amphibian species. Based on locality records of 145 micro-endemic species we draw buffered areas

within the AMBAs, before we may sensibly recommend a conservation strategy.

This tool is only a coarse scale filter and should certainly not be used as the single tool for selecting and prioritizing strategies that could be implemented in the field. Nevertheless, because it is specifically focused on existing conservation instruments and their implementation feasibility, it becomes a basic starting point to reduce the gap between assessment and implementation while proposing an overarching conservation strategy. Based on these considerations, the use of this tool would be useful to allocate (or re-allocate) resources to different sites within a country or region to reinforce and enlarge a pre-existing conservation strategies networks. This triage tool could also ultimately help to identify places too devastated to

SalaMarker: A code generator and standardized marking system for use with visible implant elastomers

Jami E. MacNeil, Guha Dharmarajan, & Rod N. Williams

Many amphibian species are challenging to sample due to their small size and cryptic life histories. For these species, estimates of population size and demographic parameters such as birth, death, and survival rates can be improved by applying unique identifying marks to individuals. Visible implant elastomers (VIEs) provide lasting tags for small animals such as frogs and salamanders which are otherwise difficult to mark. VIE tags may be applied in different colors and body locations to create unique combinations that may be used as batch or individual marks. Despite the widespread use of VIEs, few standardized coding systems have been proposed, and those that do exist are applicable only to a limited number of



Eastern red-backed salamander (*Plethodon cinereus*) marked with yellow and orange VIE tags. Based on our code nomenclature and the numbered body locations indicated, the tags form the mark Y1O3Y4. Photo: Jami MacNeil.

species. Furthermore, it is complicated and time-consuming for researchers to create independent coding schemes. To assist with future studies that use VIEs, we have created a system of code nomenclature and a computer program that will generate lists of unique marks based on the users' parameters. The code nomenclature involves a simple alphanumeric system in which colors are represented by letters and body locations are represented by numbers (e.g. R1B4). This system is space-efficient, allowing mark designations to fit easily on a datasheet, and can be applied to any animal as long as the body locations are numbered. The code generator SalaMarker creates an output of all possible codes based on the user's preference of body locations, number of tags per individual, and any number and combination of colors. The .txt output file can be printed or copied into spreadsheet or word document programs. This system of denoting VIE combinations coupled with a new code generator may save researchers time and effort spent creating such a code from scratch and may prevent errors that result from manually entering letter codes into a spreadsheet. The program is available for free online at: <http://web.ics.purdue.edu/~rodw/> under the heading "SalaMarker."

Full article: MacNeil, J. E., Dharmarajan, G., & R. N. Williams. (2011). SalaMarker: A code generator and standardized marking system for use with visible implant elastomers. *Herpetological Conservation and Biology*. 6: (260-265).

Habitat use and movement of the endangered arroyo toad (*Anaxyrus californicus*) in coastal southern California

By Milan J. Mitrovich, Elizabeth A. Gallegos, Lisa M. Lyren, Robert E. Lovich, & Robert N. Fisher

Little is known about the habitat use and land movement patterns of arroyo toads (*Anaxyrus californicus*), especially with regards to upland use in coastal areas. We tracked 40 adult toads with radio-transmitters from a single site in coastal southern California from March through November of 2004. There was concentrated activity by both male and female toads along stream terraces during and after breeding, and, although our fall sample size is low, there was a continued presence of adult toads in the floodplain through the late-fall. Adult toads used open sandy flats with sparse vegetation. Home range size and movement frequency varied as a function of body mass. Observed spatial patterns of movement and habitat use during and outside of the breeding period, as well as available climatological data suggests overwintering of toads in floodplain habitats of near-coastal areas of southern California may be more common than previously considered. If adult toads are not migrating out of the floodplain at the close of the breeding season but instead overwinter on stream terraces in near-coastal areas, then current management practices that assume toad absence from floodplain habitats may be leaving adult toads over-wintering on stream terraces vulnerable to human disturbance during a time of year when arroyo toad mortality is

potentially highest.

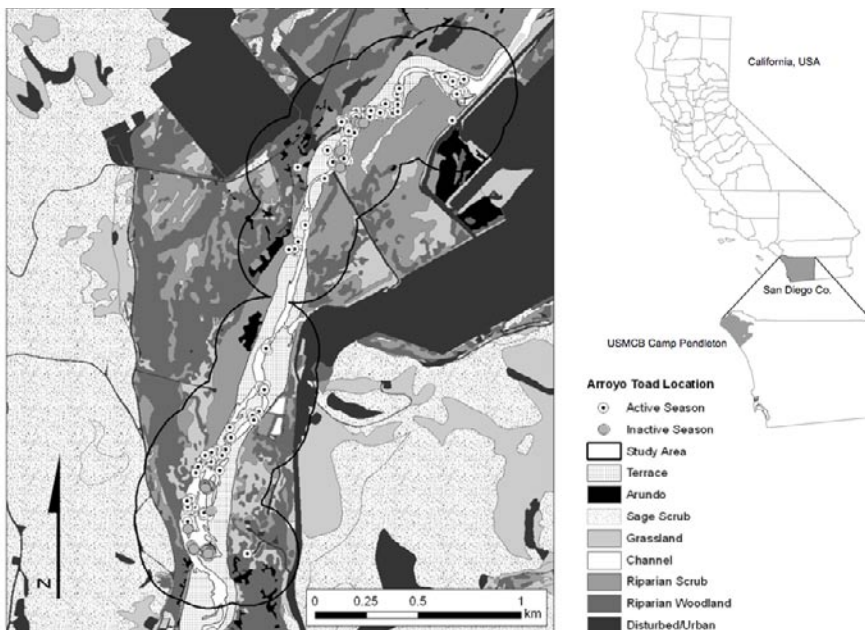
Full article: Mitrovich, M. J. et al. (2011). Habitat use and movement of the endangered arroyo toad (*Anaxyrus californicus*) in coastal southern California. *Journal of Herpetology* 45(3):319-328.

Biomass export of salamanders and anurans from ponds is affected differentially by changes in canopy cover

By Julia E. Earl, Thomas L. Luhring, Bethany K. Williams, & Raymond D. Semlitsch

Changes in tree canopy cover can shift the food web from being primarily based on algae in open canopy ponds to dead leaves in closed canopy ponds. This shift has been shown to reduce tadpole performance. However, salamanders may be affected differently, because they are carnivores. To examine the effects of canopy cover on salamanders, and on the export of amphibian biomass from ponds, we performed an experiment in artificial ponds with two treatments: shading (high or low) and dead plant material (leaves or grass) on spotted salamanders (a forest specialist) and small-mouthed salamanders (a habitat generalist). We also reanalyzed data from Williams, Rittenhouse & Semlitsch (2008) to look at shading and dead plant effects on biomass export of three frogs: southern leopard frogs, spring peepers and eastern gray treefrogs. Contrary to previous work, salamanders performed better in closed canopy ponds (high shade and leaves), which resulted in a greater biomass export. Salamanders had a larger size at metamorphosis under closed canopy conditions, likely due to treatment-related differences in prey abundance, such as midge larvae. Frogs, in contrast, produced lower biomass export under closed canopy conditions (leopard frogs and spring peepers) or were not affected by canopy (treefrogs). Our study and others suggest that canopy cover alteration may result in a shift in the type of amphibians leaving ponds from mostly frogs and toads in open canopy ponds to mostly salamanders in closed canopy ponds. Additional community studies will resolve whether trends are consistent with higher amphibian diversity. Further studies on canopy cover effects on salamanders will help researchers understand aquatic-terrestrial linkages.

Full article: Earl, J.E. et al. (2011). Biomass export of salamanders and anurans from ponds is affected differentially by changes in canopy cover. *Freshwater Biology* 56: 2473-2482. jee9rb@mizzou.edu.



Arroyo toad locations and land cover types during the active and inactive season (2004) on the Santa Margarita River study site at the US Marine Corps Base, Camp Pendleton, CA. Study area is delimited by a 250-m buffer for all toad locations.

Seasonal microhabitat selection and use of syntopic populations of *Lithobates okaloosae* and *Lithobates clamitans clamitans*

By Thomas A. Gorman and Carola A. Haas

Quantifying and comparing habitat selection of related, syntopic species may help elucidate how species partition resources and compete. The Florida Bog Frog (*Lithobates okaloosae*) is endemic to northwestern Florida and is syntopic with the more widely distributed Bronze Frog (*Lithobates clamitans clamitans*). Our objective was to determine whether these closely related frogs selected different microhabitat characteristics at male calling sites, which in turn may influence successful reproduction or survival. From 2006 to 2008, we quantified microhabitat characteristics of male calling sites used by both species on Eglin Air Force Base, Florida. We created a suite of a priori models and used paired logistic regression to assess each species' habitat selection. Further, we compared habitat characteristics from each species' most highly supported model to directly compare habitat use. Model



Male *Lithobates okaloosae* at a calling site on Eglin Air Force Base, Florida. Photo: Thomas Gorman.

selection indicated that calling sites for *L. okaloosae* were best described by habitat features related to microhabitat cover (i.e., submergent vegetation, emergent vegetation, woody debris, frog-level canopy cover, distance to cover), whereas *L. c. clamitans* selected sites based on features that may be favorable for female oviposition or egg development (i.e., depth, water movement, depth x water movement interaction). Further, *L. c. clamitans* selected sites with 3.7 times less submergent vegetation and 1.6 times greater water depths than *L. okaloosae*. At this scale, these ranids select microhabitat differently; however, there is overlap among some selected variables. The habitat characteristics used by *L. okaloosae* may be associated with fire in the uplands and occasionally in the wetlands.

Full article: Gorman, T. A. and C. A. Haas. 2011. Seasonal microhabitat selection and use of syntopic populations of *Lithobates okaloosae* and *Lithobates clamitans clamitans*. *Journal of Herpetology* 45:313-318.

The Amphibians and Reptiles of Sulawesi: underestimated Diversity in a dynamic Environment

By André Koch

Compared with the very diverse herpetofauna of the three Greater Sunda Shelf Islands, the diversity of amphibians and reptiles on Sulawesi is impoverished. Due to their limited ability to colonize new island territories, frogs are particularly poor in species on Sulawesi and other islands within the oceanic Wallacea transition zone. Currently, they are represented by only five anuran families on Sulawesi with about 40 recognized species. The oceanic character of the herpetofauna is the result of the million-year-long geographic isolation of Sulawesi which is separated from surrounding islands by deep ocean trenches since about 40 Mya. However, despite ambitious investigations by several industrious scientists during the past two centuries, recent fieldworks on Sulawesi and its smaller off-shore islands has revealed that the diversity of amphibians and reptiles has been largely underestimated and neglected. For instance, the last description of an anuran species from Sulawesi was published 80 years ago! Recently, however, the interest in the island's frogs has experienced a revival. Since the last herpetological synopsis was published in 1996, 30 new amphibian and

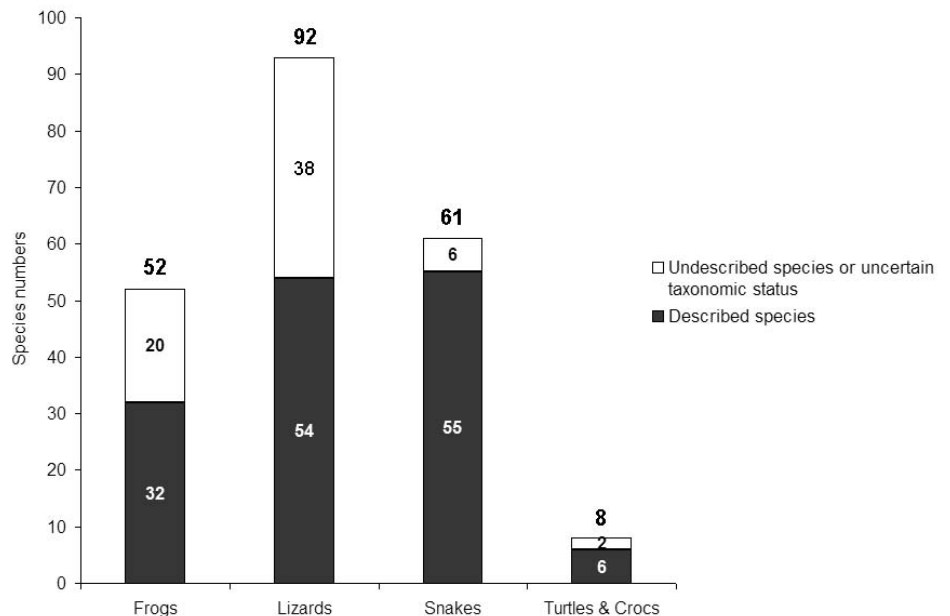
reptile species plus five subspecies have been described or newly recorded for Sulawesi and its satellite islands. In addition, more than 40 species, mainly skinks and frogs, have been identified as new to science and await formal description. Alone within the genus *Limnonectes*, nine undescribed endemic species have been identified. This represents an increase in species numbers by more than 35%! In total, about 210+ different species of amphibians and reptiles are currently recognized from the Sulawesi region almost 60% of which are endemics.

Full article: Koch, A. (2011) The Amphibians and Reptiles of Sulawesi: underestimated Diversity in a dynamic Environment. pp. 383-404 in: Zachos F.E. and Habel J.C., eds. *Biodiversity Hotspots. Distribution and Protection of Conservation Priority Areas*. Heidelberg: Springer, 546 pp.

Adaptive monitoring using the endangered northern corroboree frog (*Pseudophryne pengilleyi*) as a case study

By Francis L. Lemckert, Trent D. Penman and Andrew Haywood

Monitoring programs are most successful when they undertake regular evaluation of their data to determine if the goals of the programs are achievable and allow changes to achieve this as necessary – so called adaptive monitoring. We use data from a monitoring program for the northern corroboree frog (*Pseudophryne pengilleyi*), a declining species in south-eastern Australia, to determine the inter-



Relation between described and undescribed amphibian and reptile species of the Sulawesi region.



Figure title (Kelly Rowley): The threatened northern corroboree frog (*Pseudophryne pengilleyi*) has declined markedly since the 1970s and is now only found in large numbers in a region dominated by forestry activities including pine plantations

annual variability in the counts and assess what levels of population change would be detectable using different statistical and monitoring approaches. We determined that the existing monitoring program would only successfully statistically detect a 3% annual decline (34% total decline) in population size over a ten year period. Monitoring 40 sites would allow an 80% or greater chance of detecting a 2% or greater annual increase over a ten year period (22% increase). Detecting population decreases is more difficult as monitoring 40 sites with a 2% annual decline (19% total decline) will have a less than 40% chance of being detected after 10 years. A larger monitoring program is required to detect smaller annual changes in the population of this species and could be achieved by combining results from monitoring being undertaken in the region. These findings have implications for the likely effectiveness of other anuran monitoring programs as the northern corroboree frog appears to be far more consistent in detectable call effort compared to most species.

Full article: Lemckert, F., Penman, T. & Haywood, A. 2011. Adaptive monitoring using the endangered northern corroboree frog (*Pseudophryne pengilleyi*) as a case study. *Proc. Int. Acad. Ecol. Environ Sci.* 1:87-96.

Climate Change and American Bullfrog Invasion: What Could We Expect in South America?

By Javier Nori, J. Nicolas Urbina-Cardona, Rafael D. Loyola, Julián N. Lescano & Gerardo C. Leynaud

Biological invasion and climate change pose challenges to biodiversity conservation in the 21st century. Invasive

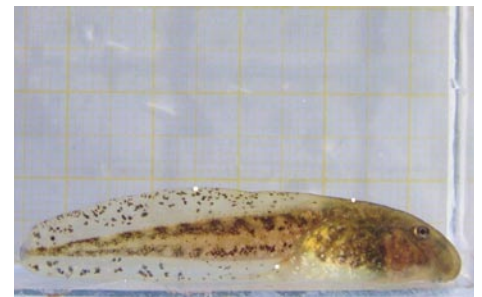
species modify ecosystem structure and functioning and climatic changes are likely to produce invasive species' range shifts pushing some populations into protected areas. The American Bullfrog (*Lithobates catesbeianus*) is one of the hundred worst invasive species in the world. Native from the southeast of USA, it has colonized more than 75% of South American countries where it has been reported as a highly effective predator, competitor and vector of amphibian diseases. We modeled the potential distribution of the bullfrog in its native range based on different climate models and green-house gases emission scenarios, and projected the results onto South America for the years of 2050 and 2080. We also overlaid projected models onto the South American network of protected areas. Our results indicate a slight decrease in potential suitable area for bullfrog invasion, although protected areas will become more climatically suitable. Therefore, invasion of these sites is forecasted. We provide new evidence supporting the vulnerability of the Atlantic Forest Biodiversity Hotspot to bullfrog invasion and call attention to optimal future climatic conditions of the Andean-Patagonian forest, eastern Paraguay, and northwestern Bolivia, where invasive populations have not been found yet. We recommend several management and policy strategies to control bullfrog invasion and argue that these would be possible if based on appropriate articulation among government agencies, NGOs, research institutions and civil society.

Full article: Nori J, Urbina-Cardona JN, Loyola RD, Lescano JN, Leynaud GC (2011) Climate Change and American Bullfrog Invasion: What Could We Expect in South America? *PLoS ONE* 6(10): e25718. doi:10.1371/journal.pone.0025718

Survival of *Alytes cisternasii* tadpoles in stream pools: a capture-recapture study using photo-identification.

By Joana Ribeiro & Rui Rebelo

Amphibians have distinctively complex life cycles and populations are regulated in each life stage, by different stage-characteristic factors. However, despite the importance of larval community dynamics for adult populations, there is an important gap on our knowledge because of the paucity of studies focused on the larval stage. We performed a two-month capture-recapture study on 646 photo-identified tadpoles of *Alytes cisternasii* and aimed to estimate tadpole survival in isolated temporary stream pools, assessing how pool characteristics and intraspecific competition (tadpole density) affect this parameter. We used program I³S to perform the photo-identification and the POPAN formulation (Jolly-Seber model) to estimate survival rates and population size in 9 pools. Tadpole density varied from ~1 to 40 tadpoles · m⁻² and weekly survival was high,



A. cisternasii tadpole inside the acrylic box used for the photographs. The white dots represent the reference system used during the photo-identification process. Photo: Joana Ribeiro.

varying from 75 to 99% · week⁻¹. Survival appeared to be affected only by pool depth, as the lowest estimates were registered for the deep pools. Other pool characteristics and tadpole density did not seem to be significantly influent on tadpole survival. The fact that some survival estimates were surprisingly high indicates the paramount importance of these discrete habitats for this and other Mediterranean species. As far as we know, this is the first study to use photo-identification on tadpoles to successfully estimate demographic parameters.

Full article: Ribeiro, J., Rebelo, R. (2011): Survival of *Alytes cisternasii* tadpoles in stream pools: a capture-recapture study using photo-identification. *Amphibia-Reptilia* 32: 365-374.

Quantitative recommendations for amphibian terrestrial habitat conservation derived from habitat selection behavior

By Lukas Indermaur, & Benedikt R. Schmidt

Hitherto, amphibian habitat conservation focused mostly on aquatic habitats. However, most species of amphibians spend most of their time in terrestrial habitats away from the breeding sites. There are few recommendations for the conservation of terrestrial habitats of amphibians that can be used by conservationists. Here, we use data from a radio-tracking study on two species of toads (*Bufo bufo* and *Bufo viridis*) to derive such recommendations. Toads were radiotracked in a dynamic, undisturbed floodplain of the Tagliamento river in northern Italy. A previous study showed that toads prefer wood deposits over other habitat types. In the Tagliamento floodplain, wood deposits were in open areas; they were not found within forested areas (i.e. they are not simply coarse woody debris). Wood deposits are used as shelter and for foraging. We now show how much wood deposits a single toad needs. A habitat dependence analysis showed that toads increase the size of the home range until an amount of wood deposits is included in the home range. For *Bufo bufo*, this amount was 47 m² and for *Bufo viridis* the amount was 67 m². We suggest that creating wood deposits is a simple way to increase the quality of terrestrial habitat for amphibians, especially in agricultural areas. This study is also an example of how data on animal behavior (habitat selection) can be used to derive recommendations for conservation. Furthermore, the study shows how quantitative recommendations used directly by conservationists can be derived.

Full article: Indermaur, L., Schmidt, B. R. 2011. Quantitative recommendations for amphibian terrestrial habitat conservation derived from habitat selection behavior. Ecological Applications 21: 2548-2554.

Frogs, Fish and Forestry: An Integrated Watershed Network Paradigm Conserves Biodiversity and Ecological Services

By Hartwell H. Welsh, Jr.

Habitat alterations are a primary cause of amphibian declines worldwide, with deforestation probably the single greatest source of altered habitats in forest-dominated biomes. In this paper, I examine the impacts of commercial forestry operations on several stream-dwelling



A large wood deposit in the floodplain of the Tagliamento river: A preferred habitat of toads. Photo: Benedikt Schmidt

amphibians in the U. S. Pacific Northwest (PNW). I review multiple studies that link declines in the distributions and abundances of the southern torrent salamander (*Rhyacotriton variegatus*) and the coastal tailed frog (*Ascaphus truei*) to timber harvest operations adjacent to low-order (i.e. headwater) streams in the southern PNW. The studies examined impacts to these lotic amphibians at multiple spatial scales - regional, watershed, channel type, and micro-environment, ultimately linking their declines to increases in stream temperatures and fine sediment loads in the most numerous, yet least protected portions of stream networks, headwater tributaries. Emphasizing headwaters (1st to 3rd-order) channels, I discuss landscape-scale disturbance regimes and how their fluvial and geomorphic processes differentially determine the structuring of channels, their internal environments, and the composition of the resident biota. I examine the dependence of these amphibians on specific channel attributes, and discuss the links between their abundances, altered attribute states, and natural and anthropogenic disturbances. Based on the unifying concept of hydrologic connectivity, I illustrate how headwater amphibians can serve as bio-indicators of system condition and the ability of stream networks to provide vital downstream ecological services such as robust populations of commercially valuable salmonids species. I argue that managing watersheds based on the combined concepts of dendritic networks, disturbance domains, the stream continuum, and hydrologic connectivity provides an integrated paradigm that would help better maintain all the components of watersheds and the interacting processes that comprise their ecological integrity. The goal of maintaining whole catchment biodiversity and ecological services could be improved by managing watersheds based on these integrated science-

based network organizing concepts and evaluating and adjusting outcomes with a suite of responsive bio-indicators such as amphibians.

Full article: Welsh, H.H., Jr. 2011. Frogs, fish, and forestry: an integrated watershed network paradigm conserves biodiversity and ecological services. Diversity 2011, 3, 503-530; doi:10.3390/d3030503.

Impact of an invasive crayfish on adult and larval amphibians

By Gentile Francesco Ficetola

Alien invasive species are a major threat to amphibians: early assessment of their impact is crucial to set up timely management, but often the impact is evident when is too late for action. The North American crayfish, *Procambarus clarkii*, invades wetlands at the global scale, and may have negative consequences on amphibians.

We monitored an area of Northern Italy recently invaded by the crayfish, to assess its early impact on the distribution of native amphibians, and on the abundance of their larvae. We assessed whether considering measures of reproductive success provide a more prompt measure of impact than



The American red swamp crayfish, *Procambarus clarkii*. Photo: G.F. Ficetola

considering whether amphibians are present or absent from invaded wetlands.

In terms of breeding site distribution, only two amphibians (smooth newt *Lissotriton vulgaris* and Italian tree frog *Hyla intermedia*) were negatively associated with the crayfish, while the relationship between other species and *P. clarkii* was positive or not significant. However, larval abundance for all amphibian species was negatively associated with alien crayfish. Analyses performed at community and single species levels yielded consistent results.

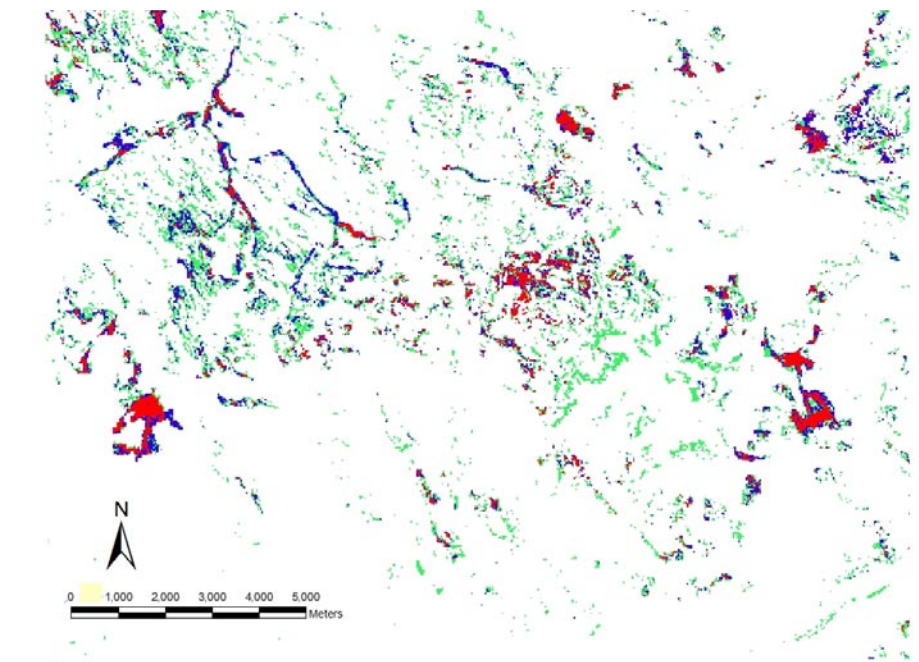
Procambarus clarkii impacts amphibians through different processes. Newts probably select uninvaded wetlands for breeding. Other species, particularly the frogs *Rana latastei* and *R. dalmatina*, attempt breeding in wetlands with crayfish, but suffer very low success because of strong predation of larvae. Considering presence / absence data alone would not provide a correct picture of the consequences of this alien species on amphibian populations; measures of reproductive success may allow a more prompt assessment of its impact.

Full article: Ficetola, G. et al., (2011). Early assessment of the impact of alien species: differential consequences of an invasive crayfish on adult and larval amphibians. Diversity and Distributions, 17: 1141–1151. (francesco.ficetola@unimib.it)

Predicting breeding habitat for amphibians: a spatiotemporal analysis across Yellowstone National Park

By Paul E. Bartelt, Alisa L. Gallant, Robert W. Klaver, Chris K. Wright, Debra A. Patla & Charles R. Peterson

Predicting amphibian breeding across landscapes can help guide land management decisions and help biologists better understand and remediate factors contributing to declines in amphibian populations. We built geospatial models of likely breeding habitats for each of four amphibian species that breed in Yellowstone National Park (Yellowstone). We used field data collected in 2000–2002 from 497 sites among 16 basins and predictor variables from geospatial models produced from remotely sensed data (e.g., digital elevation model, complex topographic index, landform data, wetland probability, and vegetative cover). Except for 31 sites in one basin that were surveyed in both 2000 and 2002, all sites were surveyed once. Polytomous regression was used to build statistical models for each species of amphibian from (1) field survey



The number of years (2000, 2001, and 2002) that different areas for a small portion of Yellowstone National Park were predicted to be likely breeding habitat for Columbia spotted frogs (*Rana luteiventris*). (Green = 1 year; Blue = 2 years; Red = 3 years).

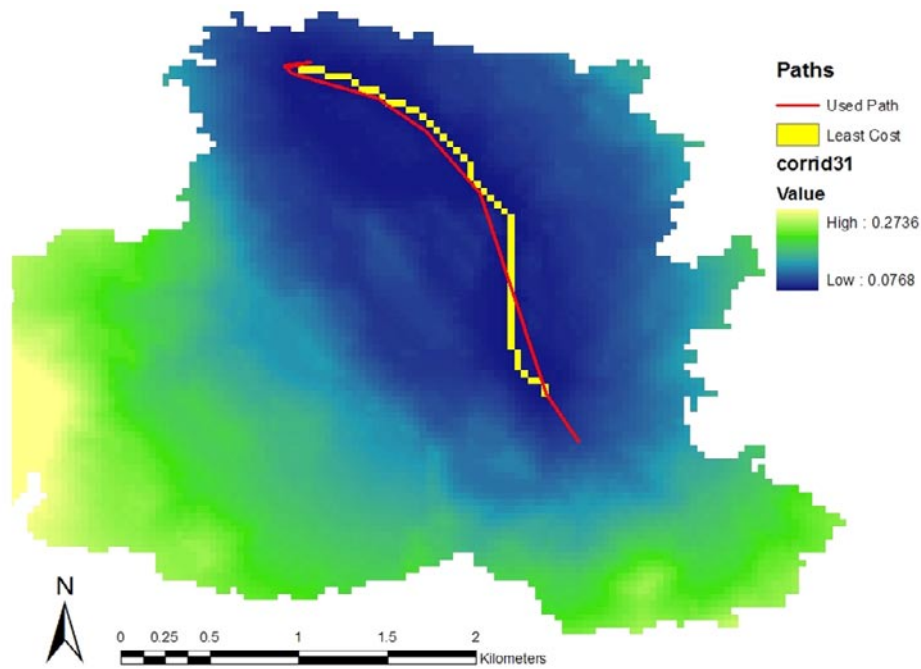
site data only, (2) field data combined with data from geospatial models, and (3) data from geospatial models only. Based on measures of receiver operating characteristic (ROC) scores, models of the second type best explained likely breeding habitat because they contained the most information (ROC values ranged from 0.70 to 0.88). However, models of the third type could be applied to the entire Yellowstone landscape and produced maps that could be verified with reserve field data. Accuracy rates for models built for single years were highly variable, ranging from 0.30 to 0.78. Accuracy rates for models built with data combined from multiple years were higher and less variable, ranging from 0.60 to 0.80. We combined results from the geospatial multiyear models to produce maps of “core” breeding areas (areas with high probability values for all three years) surrounded by areas that scored high for only one or two years; this provided an estimate of variability among years. Such information can highlight landscape options for amphibian conservation. For example, our models identify alternative areas that could be protected for each species, including 6828–10,764 ha for tiger salamanders, 971–3017 ha for western toads, 4732–16,696 ha for boreal chorus frogs, and 4940–19,690 ha for Columbia spotted frogs.

Full article: Bartelt, P.E. et al. (2011). Predicting breeding habitat for amphibians: a spatiotemporal analysis across Yellowstone National Park. Ecological Applications 21(7): 2530–2547.

Modeling amphibian energetics, habitat suitability, and movements of Western toads, *Anaxyrus (=Bufo) boreas*, across present and future landscapes.

By Paul E. Bartelt, Robert W. Klaver & Warren P. Porter

Effective conservation of amphibian populations requires an ability to predict how amphibians use and move through a landscape. Because amphibians are closely coupled to their physical environment, an approach that uses the physiological attributes of amphibians, together with knowledge of their natural history, should be helpful. We used Niche Mapper™, a suite of models that uses first principles of environmental biophysics to combine features of topography, climate, land cover, and animal features to model microclimates and animal physiology and behavior across landscapes. We used it to model the known movements and habitat use patterns of a population of Western toads (*Anaxyrus boreas*) occupying forested habitats in southeastern Idaho. Niche Mapper reproduced core body temperatures and evaporation rates of live toads with average errors of $1.6 \pm 0.4^\circ\text{C}$ and 0.8 ± 0.2 g/h, respectively. It reproduced similar mid-summer daily temperature patterns as those measured in the field among four different habitat types, and calculated evaporation rates (g/h) with an average error rate of $7.2 \pm 5.5\%$. Sensitivity analyses indicate these errors do not significantly affect estimates of food consumption or activity. Using Niche Mapper we predicted the daily



Using rates of EWL and cost-analysis to predict the movement of toad #31 across the study landscape.

habitats used by free-ranging toads; our accuracy for female toads was greater than for male toads (74.2±6.8% and 53.6±15.8%, respectively), reflecting the stronger patterns of habitat selection among females. Using these results to construct a cost surface, we also reconstructed movement paths that were consistent with field observations. The effect of climate warming on toads depends on the interaction of temperature and atmospheric moisture. If climate change occurs as predicted, results from Niche Mapper suggests that climate warming will increase the physiological cost of landscapes thereby changing the activity for toads in different habitats.

Full article: Bartelt, P.E. et al. (2010). Modeling amphibian energetics, habitat suitability, and movements of western toads, *Anaxyrus (=Bufo) boreas*, across present and future landscapes. *Ecological Modelling* 221: 2675–2686.

Erratum Citation: Bartelt, P.E. (2010). Erratum to “Modeling energetics, habitat suitability, and movements of Western toads, *Anaxyrus (=Bufo) boreas*, across present and future landscapes” [*Ecol. Modell.* 221 (2010) 2675–2686]. *Ecological Modelling* 222: 219.

Breeding chorus indices are weakly related to estimated abundance of boreal chorus frogs

By Paul Stephen Corn, Erin Muths, Amanda M. Kissel & Rick D. Scherer

Call surveys used to monitor breeding choruses of anuran amphibians generate index values that are frequently used to represent the number of male frogs present, but few studies have quantified this relationship. We compared abundance of male Boreal Chorus Frogs (*Pseudacris maculata*), estimated using capture–recapture methods in two populations in Colorado, to call index values derived from



Adult male *Pseudacris maculata* calling at Lily Pond, Larimer County, Colorado. Photo: Stephen Corn, US Geological Survey.

automated recordings. Single index values, such as might result from large monitoring efforts, were unrelated to population size. A synthetic call saturation index (CSI), the daily proportion of the maximum possible sum of index values derived from multiple recordings, was greater in larger populations, but the relationship between CSI and abundance was not highly predictive.

Full article: Corn, P.S. et al. (2011) Breeding chorus indices are weakly related to estimated abundance of boreal chorus frogs. *Copeia* 2011; 365-371.

Tadpoles fail to activate inducible defenses against invasive predatory crayfish

By Ivan Gomez-Mestre and Carmen Diaz-Paniagua

Invasive species rank among the top causes for global amphibian declines. Amphibian larvae are often capable of producing inducible defenses against predators, including reduced activity and shifts in morphology and/or pigmentation. However, the activation of such inducible defenses critically depends upon predator cue recognition, and recognition of novel invasive predators may take some time to evolve. Red swamp crayfish have been introduced in many aquatic systems in Europe, causing local declines and extinction of amphibian populations. It was introduced in Doñana National Park (SW Spain) in the 1970's, and it has since unevenly spread across the park. We show that *Rana perezi* (= *Pelophylax perezi*) tadpoles from Doñana reduce their activity and increase their tail depth and pigmentation in response to non-lethal presence of native dragonfly nymphs, hence increasing tadpole survival. However, *R. perezi* tadpoles fail to activate these defenses in the presence of invasive crayfish, even if proven experimentally that they would have increased tadpole odds of survival against crayfish. Moreover, we tested whether naïve frog populations and populations with over 30 years of exposure to crayfish differed in their responsiveness to crayfish. They did not, indicating that local adaptation to invasive crayfish has not yet had time to evolve in this system.

Full article: Gomez-Mestre, I., & Díaz-Paniagua, C. 2011. Invasive predatory crayfish do not trigger inducible defences in tadpoles. *Proceedings of the Royal Society B: Biological Sciences*. DOI:10.1098/rspb.2010.2762

The Gut of Red-backed Salamanders (*Plethodon cinereus*) May Serve as a Reservoir for an Antifungal Cutaneous Bacterium

By Patrick J. Wiggins, Jacob M. Smith, Reid N. Harris & Kevin P. C. Minbiole

Janthinobacterium lividum is a common bacterium that inhibits the growth of the lethal amphibian pathogen *Batrachochytrium dendrobatidis*. *J. lividum* has been found in a variety of environments, including streams, ponds, and the skins of amphibians that resist the fungus. Our group has gathered evidence that the gastrointestinal tract of *Plethodon cinereus*, the eastern red-backed salamander, can serve as a reservoir for *J. lividum*. Two of six individuals collected from a natural wooded environment harbored *J. lividum* in the gut tube. Violacein, a secondary metabolite whose intense violet color allows for rapid visual detection and chemical analysis, served as a first indicator for the presence of *J. lividum*. The identity of *J. lividum* was confirmed by PCR amplification with *J. lividum*-specific primers. Because *J. lividum* survives in the digestive tract, it will likely be inoculated onto skin around the cloaca and into the soil and indirectly onto salamander skins, thus allowing the gut to act as a reservoir for this antifungal bacterium. This may further support the strategy of probiotic addition of beneficial bacteria to areas where amphibians are threatened by *B. dendrobatidis*.

Full article: Journal of Herpetology, Vol. 45, No. 3, pp. 329–332, 2011

Hotspots, conservation and diseases: Madagascar's megadiverse amphibians and the potential impact of chytridiomycosis

Stefan Lötters, Dennis Rödder, Jos Kielgast & Frank Glaw

Worldwide amphibian diversity is threatened through the emergence of the disease chytridiomycosis, caused by the amphibian chytrid fungus. This pathogen apparently is still absent from the amphibian hotspot Madagascar. However, an extinction risk assessment based on environmental niche modelling suggests that a major portion of this island is climatically highly suitable to the fungus, including regions of high amphibian species richness. Many frog species have their entire geographic range in such areas

and are at the same time predicted to suffer potentially from chytridiomycosis due to their life history traits. Future human-mediated dissemination of the chytrid fungus to Madagascar is considered to be likely. In particular, there may be a high risk of accidental co-introduction via the animal trade. Severe decline and possibly extinctions are expected in a post-emergence scenario on Madagascar with the 268 described and numerous undescribed anuran species under threat. Effective responses to this potential threat might include (1) an increased attention to 'biosecurity', including the consequent implementation of measures to avoid the introduction of the chytrid fungus, (2) the development of breeding procedures for representatives of all major clades of Madagascan amphibians as a 'pre-emergency prophylaxis' and (3) the development of plans for 'emergency response'.

Full article: Lötters, S., D. Rödder, J. Kielgast & F. Glaw (2011): Hotspots, conservation and diseases: Madagascar's megadiverse amphibians and the potential impact of chytridiomycosis. In: Zachos, F. & J. Habel (eds): Biodiversity hotspots. Distribution and protection of conservation. Springer Verlag, Berlin etc. (Germany), 546 pp.: 255-274.

Ambient ultraviolet B radiation decreases the prevalence of infection by *Batrachochytrium dendrobatidis* in two amphibian species

By Manuel E. Ortiz-Santaliestra, Matthew C. Fisher, Saioa Fernández-Beaskoetxea, María J. Fernández-Benítez & Jaime Bosch

The chytrid fungus *Batrachochytrium dendrobatidis* (*Bd*) is responsible for declines and extinctions of amphibian populations worldwide. Several sources of stress such as global warming or environmental pollution have been suggested as potential cofactors conditioning the spread and increase of virulence of the pathogen. Another potential cofactor could be the increasing intensity of ultraviolet B (UV-B) radiation that reaches the Earth's surface because of the depletion of the ozone layer. In a field experiment conducted in Laguna Grande de Peñalara (central Spain), where the presence of *Bd* has been documented for years, we analysed the influence of environmental UV-B on the susceptibility of larval common toads (*Bufo bufo*) to become infected by *Bd*. Contrary to our initial hypothesis, prevalence of *Bd* was lower in tadpoles exposed to environmental UV-B doses than in tadpoles protected from the radiation. Similarly, the prevalence of *Bd* infection in many populations of common midwife toads (*Alytes obstetricans*) across the Iberian Peninsula was inversely correlated with the intensity of UV-B. Our results highlight the complexity of interactions among stressors involved in amphibian declines, as well as the importance of conducting experimental research to understand the reasons behind the spread and severity of chytridiomycosis.

Full article: Ortiz-Santaliestra ME, Fisher MC, Fernández-Beaskoetxea S, Fernández-Benítez MJ, Bosch J, 2011. Ambient ultraviolet B radiation decreases the prevalence of infection by *Batrachochytrium dendrobatidis* in two amphibian species. Conservation Biology 25, 975-982



Experimental setup used to analyze the environmental UV-B on the susceptibility of larval common toads (*Bufo bufo*) to *Batrachochytrium dendrobatidis*.

Differential host susceptibility to *Batrachochytrium dendrobatidis*, an emerging amphibian pathogen

By Catherine L. Searle, Stephanie S. Gervasi, Jessica Hua, John I. Hammond, Rick A. Relyea, Deanna H. Olson & Andrew R. Blaustein

Global declines in amphibian populations are due to many factors, including infectious disease. In particular, the fungal pathogen, *Batrachochytrium dendrobatidis* (*Bd*), has been associated with amphibian population declines and die-offs in many locations. However, some amphibian populations appear to be persisting even in the presence of *Bd*. While environmental factors may be partly responsible for these observed differences in *Bd* susceptibility, there may also be species-specific differences in susceptibility. We experimentally tested susceptibility to *Bd* of 6 amphibian species at the post-metamorphic stage. We exposed individuals of each species to *Bd* for 30 days and monitored mortality, feeding rates and infection levels. In all species, exposure to *Bd* increased rates of mortality, but species differed in their rates of *Bd*-associated mortality. We did not detect differences in infection levels among species, but within species the relationship between body size and infection levels differed. This study demonstrates that amphibian species differ in susceptibility to *Bd* even under identical conditions. Information from this study may be used to optimize strategies for amphibian conservation.

Full article: Searle, C.L., Gervasi, S.S., Hua, J., Hammond, J.I., Relyea, R.A., Olson, D.H. and Blaustein, A.R. (2011) Differential host susceptibility to *Batrachochytrium dendrobatidis*, an emerging amphibian pathogen. *Conservation Biology* 25:965-974.

A dilution effect in the emerging amphibian pathogen *Batrachochytrium dendrobatidis*

By Catherine L. Searle, Lindsay M. Biga, Joseph W. Spatafora & Andrew R. Blaustein

Change in biodiversity can alter disease dynamics in complex ways. For example, the dilution effect occurs when communities high in biodiversity have lower disease risk compared to low-diversity systems. Therefore, losses in biodiversity can increase disease risk for the remaining organisms. We tested for the dilution effect in the fungal pathogen of amphibians, *Batrachochytrium dendrobatidis* (*Bd*), which is associated with amphibian population declines around the world. Little is known about how community structure and biodiversity affect *Bd* susceptibility and risk. We



Biodiversity can reduce disease risk in the western toad (*Anaxyrus boreas*). Photo by Ivan Phillipsen, Oregon State University.

experimentally tested for the effects of host diversity and density on the severity of *Bd* infection in larval amphibians. We found a dilution effect where increasing species richness decreased disease risk, even when accounting for changes in host density. This study demonstrates the importance of incorporating community biodiversity into studies of *Bd*. In regions where amphibian species are disappearing, lowered diversity may result in greater risk of infection.

Full article: Searle, C.L., Biga, L.M., Spatafora, J.W. and Blaustein, A.R. 2011. A dilution effect in the emerging amphibian pathogen *Batrachochytrium dendrobatidis*. *Proceedings of the National Academy of Sciences* 108: 16322-16326

Can differences in host behavior drive patterns of disease prevalence in tadpoles?

By Matthew D. Venesky, Jacob L. Kerby, Andrew Storfer & Matthew J. Parris

Quantifying the outcomes of host-pathogen interactions is essential for understanding the ecological implications of emerging diseases. Differences in host behavior and resistance to disease can influence the outcome of these interactions, yet the degree to which they influence pathogen transmission in natural systems is not well understood. We capitalized on the variation in aggregation behavior of Fowler's toads (*Anaxyrus* [= *Bufo*] *fowleri*) and grey treefrogs (*Hyla versicolor*) tadpoles and tested for differences in transmission of *Batrachochytrium dendrobatidis* (*Bd*) and host-specific fitness consequences (i.e., life history traits that imply fitness) of infection in single-species amphibian mesocosms. Although *Bd* transmission was low in our experiment (inferred through increases

in prevalence above the baseline starting prevalence), we observed higher intraspecific transmission in *A. fowleri* mesocosms relative to *H. versicolor*. On average, *A. fowleri* mesocosms supported higher *Bd* prevalences and infection intensities relative to *H. versicolor* mesocosms. Compared to disease-free conditions, we observed significantly more *A. fowleri* tadpoles aggregating when raised in the presence of *Bd* but observed the opposite effect among *H. versicolor* tadpoles. In addition, irrespective of species, mesocosms in which tadpoles aggregated significantly predicted *Bd* infection intensity, further supporting the idea that aggregations can increase transmission and disease risk. Lastly, we also found that tadpoles raised in the presence of *Bd* were smaller and less developed than tadpoles raised in disease-free conditions, suggesting that *Bd* appears to negatively impact larval growth and developmental rates of *A. fowleri* and *H. versicolor* similarly, even in the absence of high *Bd* prevalence.

Full article: Venesky, M.D., J. Kerby, A. Storfer, and M.J. Parris (2011) Can differences in host behavior drive patterns of disease prevalence in tadpoles? *PLoS ONE* 6(9):e24991. doi:10.1371/journal.pone.0024991

Aquatic and terrestrial stressors in amphibians: a test of the double jeopardy hypothesis using maternally and trophically derived mercury

By Brian D. Todd, Christine M. Bergeron, Mark J. Hepner, & William A. Hopkins.

Many amphibians have complex life cycles (i.e., biphasic life histories). Because such species rely on suitable habitat in both aquatic and terrestrial systems, they may face twice the risk of habitat loss or degradation compared with vertebrates that occupy only one habitat type. This increased risk has been termed



American toads (*Bufo americanus*) were collected from the riparian zone of a mercury-contaminated river in northern Virginia, USA. Photo: B. Todd.

“double jeopardy”. Globally, environmental contaminants are increasingly a cause of degradation that can affect either aquatic or terrestrial habitats.

We studied the degree to which double jeopardy confronts amphibians exposed to aquatically- and terrestrially-derived environmental contaminants. We collected adult American toads (*Bufo americanus*) from the riparian zone of a mercury-contaminated river in northern Virginia, USA. Adult toads had accumulated high levels of mercury while foraging as terrestrial animals. After allowing adults to mate and lay eggs in the lab, we examined the individual and interactive effects of this earlier terrestrial exposure on offspring that were either exposed or not exposed to dietary mercury as aquatic larvae. We found evidence of negative effects in offspring that resulted from both terrestrial exposure and aquatic exposure but we did not find any additive or synergistic effects from combined exposure. Although aquatic exposure in larval diet resulted in a trend of decreased survival, the effects of terrestrial maternal exposure were sublethal and more pervasive. Offspring from mercury-exposed mothers weighed less, took longer to metamorphose, and had more than twice as many spinal malformations as those from uncontaminated reference mothers. The results of our study support the idea that amphibians with complex life histories face a double jeopardy of risk from degradation that can affect either aquatic habitats or terrestrial habitats.

Full article: Todd BD, Bergeron CM, Hepner MJ, Hopkins WA. 2011. Aquatic and terrestrial stressors in amphibians: a test of the double jeopardy hypothesis using maternally and trophically derived mercury. Environmental Toxicology & Chemistry 30(10):2277-2284.

Toes versus Swabs? Evaluation of The Best Tissue Source for Detection of *Batrachochytrium dendrobatidis* in Field-Caught Amphibians.

By Burrowes, P. A., Alicea, A., Longo, A. V. & Joglar, R. L.

The probability of accurately detecting *Batrachochytrium dendrobatidis* (*Bd*) on infected frogs is an important issue for studies on the mechanisms of *Bd* through ex-situ experiments or in the field. This study evaluates the reliability of these two sampling methods applied to the same animal, in detecting *Bd* and estimating the intensity of the infection in the field at a given sampling time. Toe-clips and ventral

skin swabs were taken from 85 individuals (55 adults and 30 juveniles) in four species of direct-developing frogs in the genus *Eleutherodactylus* from Puerto Rico. Frogs were sampled in the field from populations known to be *Bd* positive. *Bd* loads (number of zoospores genomic equivalents) per sample were quantified via quantitative PCR. Results revealed no significant difference in the probability of detecting *Bd* from toe-clips or swabs, regardless of species, age group, or locality studied. The *Bd* infection intensities estimated by swabs versus toes, when at least one of the two tissue sources was positive, were not significantly different when all frogs are considered. However, when age groups were considered, toes estimated a significantly greater number of zoospores than swabs in adult frogs only. The study discusses the advantages and disadvantages of collecting both types of tissues and their applicability for studies other than the dynamics of *Bd*-infection in an amphibian community, and recommends the use of swabbing as the main sampling technique for *Bd* detection.

Full article: Burrowes, P. A., Alicea, A., Longo, A. V., and Joglar, R. L. 2011. Toes versus Swabs? Evaluation of The Best Tissue Source for Detection of *Batrachochytrium dendrobatidis* in Field-Caught Amphibians. Herpetological Review 42(3):359–362.

Additional reports of the amphibian chytrid fungus *Batrachochytrium dendrobatidis* from Georgia, USA

By Robert L. Hill, Michael G. Levy, Elizabeth K. Timpe & Julia B. Kaylock

The amphibian fungal pathogen *Batrachochytrium dendrobatidis* (*Bd*) appears to be widespread within the southeastern United States despite relatively few surveys to document its location or potential effects. The state of Georgia is home to a large and diverse assemblage of amphibians, in particular salamanders (>50 described species). Our study extends the known range of *Bd* in Georgia and confirms the initial findings of previous efforts to detect this pathogen in a particularly amphibian rich region of the state. We also document the first known occurrences of *Bd* in Georgia for three species of plethodontid salamanders: Seal Salamander (*Desmognathus monticola*), Southern Two-lined Salamander (*Eurycea cirrigera*), and Red Salamander (*Pseudotriton ruber*).

We conducted surveys in four of five physiographic provinces in Georgia to document areas of occurrence.

Subsequently, these areas can be more closely monitored over time, for example to determine *Bd*'s prevalence and any potential negative impacts as have been observed in other amphibian assemblages globally. Of particular concern is the repeated detection of *Bd* within the range of the endemic Pigeon Mountain Salamander (*Plethodon petraeus*). We feel that additional sampling efforts are warranted for this and other species with restricted ranges. Field studies and laboratory experiments have demonstrated that terrestrial plethodontids may be detrimentally affected by *Bd*-induced chytridiomycosis.

Full article: Hill, R. L. et al. (2011) Additional reports of the amphibian chytrid fungus *Batrachochytrium dendrobatidis* from Georgia, USA. Herpetol. Rev. 42; 376–378. (e-mail: bobbiloma@gmail.com)

Amphibians at risk? - Susceptibility of terrestrial amphibian life stages to pesticides

By Carsten A. Brühl, Silvia Pieper & Brigitte Weber

Current pesticide risk assessment does not specifically consider amphibians. Amphibians in the aquatic environment (i.e. aquatic life-stages or postmetamorphic aquatic amphibians) and terrestrial living juvenile or adult amphibians are assumed to be covered by the risk assessment for aquatic invertebrates and fish, or mammals and birds, respectively. This procedure has been evaluated as being sufficiently protective regarding the acute risk posed by a number of pesticides to aquatic amphibian life stages (eggs, larvae). However, it is unknown whether the exposure and sensitivity of terrestrial living amphibians is comparable to mammalian or avian exposure and sensitivity.

We reviewed the literature on dermal pesticide absorption and toxicity studies for terrestrial life stages of amphibians, focusing on the dermal exposure pathway, i.e. via treated soil or direct overspray. In vitro studies demonstrated that cutaneous absorption of chemicals is significant and that chemical percutaneous passage *P* (cm/h) is higher in amphibians than in mammals. In vivo, the rapid and substantial uptake of the herbicide atrazine from treated soil by toads (*Bufo americanus*) was described. Severe toxic effects on various amphibian species have been reported for field relevant application rates of different pesticides. In general, exposure and toxicity studies for terrestrial amphibian life-stages are scarce, and the reported data indicate the need for further research especially in

the light of the 'global amphibian decline'.

It is therefore imperative to verify a sufficient protection of terrestrial amphibian life stages from unacceptable risks by using the vertebrate data from bird and mammal studies in the risk assessment of pesticides.

Full article: Brühl C.A., Pieper S. & Weber B. (2011) Amphibians at risk? - Susceptibility of terrestrial amphibian life stages to pesticides. Environ. Toxicol. Chem.: 30 (11); 2465-2472.

Environmental refuge from disease driven amphibian extinction

By Robert Puschendorf, Conrad J. Hoskin, Scott D. Cashins, Keith McDonald, Lee F. Skerratt, Jeremy VanDerWal & Ross A. Alford

Species that are tolerant of broad environmental gradients may be less vulnerable to epizootic outbreaks of disease. Chytridiomycosis, caused by the fungus *Batrachochytrium dendrobatidis*, has been linked to extirpations and extinctions of amphibian species in many regions. The pathogen thrives in cool, moist environments, and high amphibian mortality rates have commonly occurred during chytridiomycosis outbreaks in high-elevation tropical rainforests populations. In Australia several high-elevation species, including the armored mist frog (*Litoria lorica*), designated as critically endangered by the IUCN, were believed to have gone extinct during chytridiomycosis outbreaks

in the 1980s and early 1990s. Species with greater elevational ranges disappeared from higher elevations, but remained common in the lowlands. In June 2008, we surveyed a stream in a high-elevation dry sclerophyll forest and discovered a previously unknown population of *L. lorica* and a population of the waterfall frog (*L. nannotis*). We conducted a total of 6 additional surveys in June 2008, September 2008, March 2009, and August 2009. Prevalence of *B. dendrobatidis* infection was consistently high in frogs (mean 82.5%, minimum 69%) of both species and in tadpoles (100%) during both winter and summer. However, no individuals of either species showed clinical signs of disease, and they remained abundant throughout the study. The high-elevation dry sclerophyll site has little canopy cover, low annual precipitation, and a more defined dry season than a nearby rainforest site, where *L. nannotis* was more negatively affected by chytridiomycosis. We hypothesize that this lack of canopy cover allows the rocks on which the frogs perch to warm up, thereby slowing growth and reproduction of the pathogen on the hosts. In addition, we suggest surveys for apparently extinct or rare species should not be limited to core environments.

Full article: Puschendorf, R., C. J. Hoskin, Scott D. Cashins, Keith McDonald, Lee F. Skerratt, Jeremy VanDerWal, Ross A. Alford. (2011). Environmental Refuge from Disease-Driven Amphibian Extinction. Conservation Biology 25(5): 956-964.

Elevated temperature clears chytrid fungus infections from tadpoles of the midwife toad, *Alytes obstetricans*

By Corina C. Geiger, Eliane Küpfer, Sämi Schär, Sarah Wolf, & Benedikt R. Schmidt

The amphibian chytrid fungus (*Bd*) is a major threat to the survival of amphibian populations. It is necessary to develop methods that can be used to clear infections. Previous studies showed that exposure to elevated temperature may clear *Bd* infections in adult amphibians. Here we show that elevated temperature can be used to clear *Bd* infections in tadpoles of the midwife toad, *Alytes obstetricans*. Tadpoles naturally infected with *Bd* were kept individually at 21 °C, 26 °C and approximately 30 °C for five days (at the highest temperature, tadpoles were not permanently exposed to the high temperature). At the lowest temperature, most tadpoles were still infected after five days but some cleared the infection. At elevated temperatures (i.e. 26 °C and 30 °C), most tadpoles lost the infection even though a small proportion was still infected. The results thus clearly show that elevated temperature can be used to clear *Bd* infections in tadpoles even if some tadpoles may remain infected. The results may also explain why *Bd* prevalence is lower in warmer ponds and may suggest ways to mitigate the effects of *Bd* in the wild.

Full article: Corina C. Geiger, Eliane Küpfer, Sämi Schär, Sarah Wolf, Benedikt R. Schmidt. 2011. Elevated temperature clears chytrid fungus infections from tadpoles of the midwife toad, *Alytes obstetricans*. Amphibia-Reptilia 32: 276-280.



High density of waterfall frogs (*Litoria nannotis*) infected with *Bd* in open forest (picture by Robert Puschendorf)

Assessment of the Vulnerability of the Oregon Spotted Frog (*Rana pretiosa*) to the Amphibian Chytrid Fungus (*Batrachochytrium dendrobatidis*)

By Gretchen E. Padgett-Flohr & Marc P. Hayes

The Oregon spotted frog (*Rana pretiosa*) is at risk across its geographic range. Discovery of the chytridiomycete fungus, *Batrachochytrium dendrobatidis* (*Bd*), in declining populations of *R. pretiosa* raised the possibility that this etiological agent might be a contributor to these declines. This led us to experimentally examine the sensitivity of *R. pretiosa* to *Bd*. Juvenile *R. pretiosa* (4-6 g) exposed to two strains of *Bd* were followed over a 90-day post-exposure period. Though all individuals in the exposed groups became infected, no frog in either group died or showed behavioral



Rana pretiosa (Oregon Spotted Frog) Photo: Andrew O'Connor.

or morphological manifestations of disease. Moreover, by the end of the exposure period, nearly all frogs had cleared their infections, and skin sloughing hypothesized as accompanying infection clearing appeared minimal. However, frogs in both exposed groups gained significantly less mass than frogs in the control group. This experiment, and the recent discovery of *Bd* in non-declining populations of *R. pretiosa*, suggests that the species is *Bd* resistant. We remain cautious in this conclusion, as tested animals were obtained from a population in decline; so tested frogs may be descendants of adults surviving a catastrophic epizootic. Lastly, minimal skin sloughing argues for investigating other mechanisms, such as antimicrobial peptide activity, as the basis for the clearing of *Bd* infections in *R. pretiosa*.

Full article: Padgett-Flohr, G.E. and Hayes, M.P. (2011) Assessment of the Vulnerability of the Oregon Spotted Frog (*Rana pretiosa*) to the Amphibian Chytrid Fungus. *Herpetological Conservation and Biology* 6(2): 99-106.

Short-Term Exposure to Warm Microhabitats Could Explain Amphibian Persistence with *Batrachochytrium dendrobatidis*

By Joshua H. Daskin, Ross A. Alford & Robert Puschendorf

Environmental conditions can alter symbiosis outcomes. Many amphibian species have declined due to chytridiomycosis, caused by the pathogenic fungus *Batrachochytrium dendrobatidis* (*Bd*), but many others persist despite high *Bd* infection prevalence. This indicates that

Bd's virulence is lower, or it may even be a commensal, in some hosts. In the Australian Wet Tropics, chytridiomycosis extirpated *Litoria nannotis* from high-elevation rain forests in the early 1990's. Although the species has recolonized many sites, no population has fully recovered. *Litoria lorica* disappeared from all known sites in the early 1990's and was thought globally extinct, but a new population was discovered in 2008, in an upland dry forest habitat it shares with *L. nannotis*. All frogs of both species observed during three population censuses were apparently healthy, but most carried *Bd*. Frogs perch on sun-warmed rocks in dry forest streams, possibly keeping *Bd* infections below the lethal threshold attained in cooler rain forests. We tested whether short-term elevated temperatures can hamper *Bd* growth *in vitro* over one generation (four days). Simulating the temperatures available to frogs on warmed

rocks in dry forests, by incubating cultures at 33°C for one hour daily, reduced *Bd* growth below that of *Bd* held at 15°C constantly (representing rain forest habitats). Even small decreases in the exponential growth rate of *Bd* on hosts may contribute to the survival of frogs in dry forests.

Full article: Daskin JH, Alford RA, Puschendorf R (2011) Short-Term Exposure to Warm Microhabitats Could Explain Amphibian Persistence with *Batrachochytrium dendrobatidis*. *PLoS ONE* 6(10): e26215. doi:10.1371/journal.pone.0026215



Sun-warmed rocks available to *Litoria nannotis* (above) and *L. lorica* in Australia's tropical dry forests may slow the growth of *Batrachochytrium dendrobatidis*. Photo: J.H. Daskin.

Call for recent publication abstracts

If you would like to include an abstract from a recent publication in this section of FrogLog please email froglog@amphibians.org. We also encourage all authors of recent publications to inform Professor Tim Halliday (formerly DAPTF International Director) (tim.r.halliday@gmail.com) of their publication in order for it to be referenced on the Amphibiaweb latest papers page. The full list of latest papers from amphibiaweb is also included in every edition of FrogLog following the recent publications abstract section.

This reference list is compiled by Professor Tim Halliday (formerly DAPTF International Director) (tim.r.halliday@gmail.com). It lists papers on amphibian declines and their causes and papers on amphibian conservation, with an emphasis on those that describe methods for monitoring and conserving amphibian populations. Tim is always delighted to receive details of forthcoming papers from their authors.

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Keep In touch

If you would like to be added to the ASG mailing list, please send an email to froglog@amphibians.org with the subject heading "add me to mailing list".

Also follow us on Facebook for regular updates on the herpetological community and the latest news from the ASG.

<http://www.facebook.com/AmphibiansDotOrg>

General Announcements

Upcoming Meetings & Workshops

Graduate and Professional Course - Species Monitoring and Conservation: Amphibians

March 26 – April 6, 2012. Smithsonian-Mason Global Conservation Studies Program at the Smithsonian Conservation Biology Institute, Front Royal, VA, USA. Visit <http://conservationtraining.si.edu> or contact SCBItraining@si.edu for more information.

Species Monitoring and Conservation: Amphibians introduces students to tools and techniques applicable to in-situ and ex-situ amphibian monitoring, research, and conservation practice, through lectures, laboratory and field exercises, and case study analyses. Topics addressed include amphibian identification and collecting, taxonomy, genetics, captive breeding and husbandry, disease, pathology, toxicology, habitat assessment, and a suite of field monitoring techniques.

This 12-day intensive course is taught by researchers from the Smithsonian Conservation Biology Institution, National Zoo, U.S. Geological Survey, Virginia Department of Game and Inland Fisheries, Towson University, and other organizations.

The course fee is \$2,500, which includes instruction and course materials as well as all meals, lodging, and transport to/from Washington-Dulles International Airport (IAD). All other travel costs and incidental expenses are the participant's responsibility. Course participants earn Continuing Education Units, or, for qualified applicants, graduate course credits are available through George Mason University at additional cost (and upon completion of further course requirements).

Additional Upcoming Courses (for more information on each of these, see <http://conservationtraining.si.edu>):

- Conservation Conflict Resolution (January 16-20, 2012)
- Spatial Ecology, Geospatial Analysis, & Remote Sensing for Conservation

(February 6-17, 2012)

- Species Monitoring and Conservation: Terrestrial Mammals (April 16-27, 2012)
- Statistics for Ecology and Conservation Biology (March 5-16, 2012)
- Non-Invasive Genetic Techniques in Wildlife Conservation (May 19-25, 2012)
- Adaptive Management for Conservation Success (June 11-22, 2012)
- Effective Conservation Leadership (2012 dates to be determined)

For information on the Applied Conservation Science Graduate Certificate see:

<http://mccs.gmu.edu/graduate/certificate>

For information on the Applied Conservation Science Professional Certificate see:

www.ocpe.gmu.edu/programs/green/applied_conservation.html

“Connecting Efforts and Identifying Gaps in Southeastern Amphibian and Reptile Conservation”

SEPARC 2012 Annual Meeting - Call for Presentation and Poster Abstracts

We are now accepting presentation and poster abstracts for the 2012 SEPARC Annual Meeting to be held at Fall Creek Falls State Park in Tennessee from February 16th-19th, 2012. Topics can include conservation efforts, land management, species status reports, legislative or regulatory policy, outreach and education, invasive species, or other relevant reptile and amphibian conservation issues.

Abstracts should contain a title, complete list of authors, and abstract body of no more than 250 words. Please include

affiliations for all authors. Please indicate the person presenting with an asterisk (*). See sample abstract below.

Abstracts should be submitted electronically to SEPARC@SEPARC.org. The subject line of the email must contain the phrase SEPARC ABSTRACT followed by the first and last name of the lead author. Please indicate whether you are submitting an abstract for an oral presentation or a poster. Any oral presentations not selected (due to time constraints) have the option of presenting as a poster.

Deadline for oral presentation submission is December 1st, 2011. Deadline for posters is Feb 6th, 2012. Registration not required for abstract submission, but will be required for final acceptance.

SAMPLE ABSTRACT - NOTE: ABSTRACT BODY: MAX 250 WORDS; SPEAKER BIO: MAX 75 WORDS.

USING THE PAST TO PREDICT THE FUTURE: REPTILE AND AMPHIBIAN CONSERVATION AND LAND-USE LEGACIES. Steven J. Price* and Michael E. Dorcas, Department of Biology, Davidson College, Davidson NC 28035

Many studies often relate the abundance or presence of amphibians and reptiles in a landscape to current land use and/or cover. From these studies, inferences are often made regarding species-habitat relationships, population ecology, and, ultimately, conservation and management. However, past land use and/or cover may be an equally or more important determinant of a species contemporary distribution across a landscape. In this presentation, we investigate the potential influence of land-use legacies on current abundance patterns of semi-aquatic reptile and amphibian species in the Charlotte Metropolitan area in North Carolina. Specifically, we use aerial imagery from the 1930s through the 2005 to quantify land use surrounding

farm ponds and first-order streams and relate current herpetofaunal abundance patterns in these habitats to their various land-use histories. We also discuss the condition of the current landscape near Charlotte and throughout the Southeast, and demonstrate how knowledge gained through studies of land-use legacies can provide valuable insights into present-day and future reptile and amphibian conservation efforts.

Steven J. Price began working at Davidson College in May 2004 after receiving his M.S. degree in Environmental Science from the University of Wisconsin-Green Bay. His research interests center around reptile and amphibian conservation biology, landscape ecology and population biology. Currently, Steve is participating in several herp projects in the sprawling Charlotte Metropolitan area, including a landscape-scale experiment on the consequences of urbanization on streams salamanders.

August 2012

7th World Congress of Herpetology.
British Columbia 8-14 August 2012.
<http://www.worldcongressofherpetology.org/?section=64>

Internships & Employment

The following information can be found at <http://www.parcplace.org/resources/job-listings.html>. Herp jobs are posted as a service to the herpetological community. If you would like to list a job opening for your organization, please send the announcement to herpjob@parcplace.org

MS Assistantship - Salamander Ecology
- Murray State University Murray, KY
(11/10/11)

Herpetologist - North Carolina Aquarium
Pine Knoll Shores, NC (11/10/11)

Coastal Biologist - North Carolina Natural Resource Program
Raleigh, NC (11/10/11)

QAQC Coordinator - Desert Tortoise Population Monitoring - Institute for Wildlife Studies Las Vegas, NV (11/9/11)

Telemetry Technicians - Desert Tortoise Population Monitoring - Institute for Wildlife Studies Mojave Desert, CA and NV (11/9/11)

Field Technicians - Desert Tortoise Population Monitoring - Institute for Wildlife Studies Mojave Desert, CA and NV (11/9/11)

Genetic Resources Collection Technician
– North Carolina Museum of Natural Sciences Raleigh, NC (11/4/11)

Postdoctoral Fellowship in Salamander Conservation and Reproductive Physiology
- Memphis Zoo Memphis, TN (11/4/11)

Amphibian Conservation Assistant
Madagascar (11/2/11)

Seasonal Herpetological Research Intern
- Alabama A&M University Bankhead National Forest, Northern Alabama (10/31/11)

Director of Conservation - The Nature Conservancy in Kansas Central Kansas
(10/25/11)

Seasonal Herpetology Research Intern
- Alabama A&M University Bankhead National Forest, northern Alabama (10/25/11)

Threatened & Endangered Species Field Biologist - Florida Fish and Wildlife Commission Holt, Florida (10/25/11)

Field Technicians (3) - Snake-bird predator-prey interactions Aiken, South Carolina (10/19/11)

Lead Desert Tortoise Monitor - Natural Resources Group, LLC Southern Nevada (10/17/11)

MS Assistantship - Desert Tortoise Research - University of California, Davis Davis, CA (10/13/11)

Postdoctoral Scientist – Landscape Ecology and Amphibian Malformations
- University of Colorado Denver, CO (10/6/11)

PhD Assistantship - Population Dynamics of Amphibians and Reptiles - Montana State University Bozeman, MT (9/25/11)

M.S. Assistantship - Wetland Amphibian Conservation Ames, IA (9/23/11)

Gopher Tortoise Biologist - the Nature Conservancy Camp Shelby, MS (9/19/11)

Assistant Professor - Vertebrate Ecology
- Purdue University West Lafayette, IN (9/16/11)

Project Manager - Department of Fish and Wildlife Conservation, Virginia Tech Blacksburg, VA (9/16/11)

Postdoctoral Fellowship - Turtle Research
- Department of Fish and Wildlife Conservation, Virginia Tech Blacksburg, VA (9/14/11)

Postdoctoral Consultant - Amphibian Conservation/Reintroduction Tanzania (9/13/11)

Biological Aid - Bog Turtle and Bat Research - Delaware Natural Heritage and Endangered Species Program Smyrna, DE (9/9/11)

Threatened and Endangered Species Habitat Specialist - National Park Service Fort Collins, CO (9/1/11)

Post Doctoral Research Associate in Dendritic Network Ecology/Amphibians
Patuxent Wildlife Research Center - Laurel, MD (8/26/11)

Herpetological Intern - Herpetological Resource and Management, LLC Lower Michigan

Scientific Assistant, Division of Vertebrate Zoology, American Museum of Natural History New York, NY

Assistant Professor Position - Human Dimensions of Wildlife Conservation - University of Florida Gainesville, FL

Assistant Curator of Reptiles and Amphibians - Carnegie Museum of Natural History Pittsburgh, PA

Crew Leader Position - Effects of Forest Management on Reptiles and Amphibians West Plains, MO

Technician Positions - Effects of Forest Management on Reptiles and Amphibians West Plains, MO

Funding Opportunities

The following information is kindly provided by the Terra Viva Grants Directory, for more information please visit: <http://www.terravivagrants.org/>.

Morris Animal Foundation -- Wildlife Health and Welfare 2012. The Morris Animal Foundation supports research projects on animal health and welfare, including wildlife. The Foundation invites proposals in several categories: Established Investigator; First Award; Fellowship Training; and Pilot Studies (small grants). The application deadline for the wildlife grants is 15 November 2011. (TVG Note: The Foundation also manages a Wildlife Rapid Response Fund to which applications can be submitted at any time.) [Link](#)

Conservation Leadership Program (CLP) -- 2012 Conservation Awards. The CLP makes grants to early-career conservationists in the developing world. Grants combine research with conservation. The CLP supports projects which have at least three team members. Future Conservationist Awards are up to US\$15 thousand. Follow-Up Awards and Leadership Awards are up to US\$25 thousand and US\$50 thousand, respectively. The deadline for applications is 18 November 2011. [Link](#)

U.S. Fish and Wildlife Service -- Wildlife Conservation in Gabon. Through its program Wildlife Without Borders - Africa, the USFWS invites proposals for capacity building to strengthen wildlife conservation in Gabon. Grants can be used for training and other capacity building. Grants will range from US\$10 thousand to US\$500 thousand. Funding Opportunity FWS-DIC-WWB-AFR2012. The application deadline is 01 December 2011. [Link1](#) [Link2](#)

EC Environment -- NGO Operating Grants 2012. The European Commission's Directorate-General for Environment calls for proposals from NGOs in the European Union for environmental projects that operate in multiple European countries. The topics are climate change; nature and biodiversity conservation; environment and health; natural resources and waste; and horizontal and cross-cutting issues. Activities outside the EU borders are eligible for funding if they provide direct added value to one or more EU member states in advancing the EU's environmental agenda. Grants are up to €900 thousand per project, or up to 70% of eligible project costs. Proposals are due by 05 December 2011. [Link](#)

Keidanren Nature Conservation Fund -- Grants 2012. The Fund supports field projects in environment, biodiversity, and natural resources in Japan and developing countries, with an emphasis on the Asia-Pacific region. Grants are to nonprofit NGOs. The average grant size is about 3 million yen for one year. Keidanren supports about 60 projects per year,

mainly outside of Japan. Applications should be submitted before 09 December 2011. [Link](#)

Weeden Foundation -- Biodiversity Conservation. The Weeden Foundation makes grants for biodiversity conservation in forest ecosystems, riparian corridors, and riverine and aquatic environments of ecological importance. Weeden's international geographical priorities are the Patagonia region of Chile, and the Altai Republic of Russia. The Foundation requests letters of inquiry (LOI) at least one month before proposal deadlines. The next deadline is 27 January 2012. [Link](#)

UK Department for Environment, Food, and Rural Affairs (Defra) -- Darwin Initiative 2012. Administered by UK's Defra in collaboration with the Department for International Development (DFID), the Darwin Initiative invites applications for scoping awards, fellowships, and the UK Overseas Territories Challenge Fund. Projects engage UK organizations with partners in the developing world for capacity building, research, and environmental education in support of biodiversity conservation. Scoping awards of up to £3 thousand are open to UK and non-UK applicants (note the change from previous years). Funding from the Overseas Territories Challenge Fund is up to £25 thousand for individuals in the UK and its overseas territories. Fellowships are available to individuals in the developing world and in the UK's overseas territories who have links with current and recent Darwin projects, and whose current work is biodiversity conservation. The Fellows are hosted at UK organizations. The closing date for 30 January 2012. [Link](#)

British Ecological Society -- Travel Grants to UK. Travel grants for ecologists from developing countries to attend the Society's meeting and conduct other professional activity in the UK. Grants of up to £2 thousand are available to fund a visit normally expected to last around 14 days. The application deadline is 01 February. [Link](#)

Peoples Trust for Endangered Species -- Worldwide Grants. The PTES makes grants to scientific researchers and conservationists for work that helps preserve endangered species, either through research or applied field work. The program offers small grants between £2 thousand and £8 thousand for projects of up to two years. It also offers continuation grants of £10 thousand to £25 thousand for follow-up projects of two to five years. PTES invites grant requests from applicants in the UK and its overseas territories, and from countries that the World Bank does not classify as high-income. The next deadline for small grants is 10 February 2012; the next deadline for continuation grants is 11 May 2012. [Link](#)

Chicago Zoological Society -- CBOT

Conservation Grants. The Chicago Zoological Society administers conservation grants funded by the Chicago Board of Trade (CBOT). The priority is for projects that directly assist in the protection of populations of threatened and endangered species -- or that help protect a specific habitat that is of high biological value, or that is substantially threatened. The Fund supports small projects, usually up to US\$5 thousand. Grants are open to chairs and officers in IUCN's SSC Specialist Group; chairs and officers in AZA/WAZA; and all interested researchers. The next application deadline is 10 February 2012. [Link](#)

Fondation Nature & Decouvertes -- Grants for Nature Protection. The foundation supports projects for nature protection in France and Francophone Africa. Applications for small grants ('coup de main') can be submitted throughout the year. Application deadlines for major projects (from €3 thousand to €30 thousand) are 15 February and 14 August. [Link](#)

New England Biolabs Foundation -- Grassroots Conservation. The Foundation makes grants to grassroots and charitable organizations to support conservation of biological diversity; ecosystem services; community food security; and marine environment. The geographical scope focuses on selected countries of the Gulf of Honduras; the Andean region; and West Africa (in addition to Papua New Guinea, Tanzania, Nicaragua, and El Salvador). Maximum grant size is US\$10 thousand, but most grants are smaller. The next deadline for letters of inquiry is 15 February 2012. [Link](#)

World Wildlife Fund (U.S.) -- 2012 Grants for Post-Graduate Education in Conservation. WWF-US supports the Russell E. Train Education for Nature Program for academic study at masters and doctoral levels anywhere in the world. Applications are invited from conservationists in selected developing countries. For applications in 2012, the eligible countries are Malawi, Mozambique, Nepal, and countries of the eastern Pacific Ocean (fisheries management in Mexico, Guatemala, El Salvador, Nicaragua, Costa Rica, Panama, Colombia, Ecuador, Peru, and Chile). The closing date for applications is 28 February 2012. [Link](#)

Mohamed bin Zayed Species Conservation Fund -- First Round of Applications 2012. The Mohamed bin Zayed Species Conservation Fund makes grants to individuals, communities, and organizations for the conservation of animal, bird, plant, and fungi species worldwide. Since its inception in 2009, the Fund has made grants for more than 500 conservation projects, mainly in the developing countries. Small grants are up to US\$5 thousand; larger grants of up to US\$25 thousand require approval by the Fund's board.

If you have any funding opportunities that you would like announced in FrogLog, please send details to James Lewis at jplewis@amphibians.org

Applications (in English) received before 29 February 2012 will be reviewed before the end of April. [Link](#)

Tourism Cares -- Worldwide Grants 2012. Tourism Cares makes grants to nonprofit charitable organizations in the USA and internationally to benefit tourism-related sites of exceptional cultural, historic, or natural significance around the world. Past grants include several for national parks, wetlands, trails, environmental education centers, etc., of importance for tourism. Applicants from (and working with) organizations in developing countries are welcome. Deadlines for letters of inquiry are 01 March 2012 and 02 July 2012. [Link](#)

John Ball Zoological Society (USA) -- Wildlife Conservation Grants 2012. The JBZS makes grants to conserve wild animals and their habitats; to improve the management of captive animals; and to develop education programs related to these objectives. Most funded projects are in developing countries. Applicants can be of any nationality, and should be associated with a recognized institution (e.g., zoo, educational institution, conservation organization, etc.). Grants range from US\$500 to US\$2,500. The deadline for applications is 05 March 2012. [Link](#)

Australia and Pacific Science Foundation -- Grants 2012. APSF makes research grants in ecology, biodiversity, and life sciences in Australia and the Southwest Pacific region. Most grants are up to A\$15 thousand per year for up to three years. Applications are due 09 March 2012. [Link](#)

U.S. Fish and Wildlife Service -- Grants for Conservation in Latin America and Caribbean 2012. The USFWS "Wildlife Without Borders" includes a regional program for Latin America and the Caribbean to

implement the Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere. Projects should take place in the region to protect sites of high conservation value associated with flagship, migratory, or endangered species of regional concern (except that projects in Mexico need to be submitted to the Mexico program, which is separate). Priority is for projects that request less than US\$50 thousand, and that are able to provide matching support. Applications can be submitted in Spanish or English before 15 March 2012. [Link1](#) [Link2](#)

Mitsubishi Corporation Foundation for the Americas (MCFA) -- Conservation and Environment. The MCFA makes grants for biodiversity conservation, sustainable development, environmental justice, and environmental education in the Americas. Eligibility is to tax-exempt 501(c)3 organizations in the USA and their equivalents in other countries. MCFA states that the ideal timing for submitting proposals is during the first quarter of the calendar year. [Link](#)

U.S. Fish and Wildlife Service -- Grants for Species Conservation 2012. As part of its program "Wildlife Without Borders," the USFWS makes grants for the conservation of selected wildlife species. These include African elephants, Asian elephants, great apes, rhinos, tigers, and marine turtles. Grants are for applied research, training, conservation management, community outreach, law enforcement, decreased human-wildlife conflicts, and other activities in conservation. Preference is for proposals that request less than US\$50 thousand. Eligibility extends worldwide to qualified and relevant government agencies, other organizations, multi-national secretariats, and individuals. Proposal deadlines are 01 April and 01 November of each year (except marine turtles, 01 April and 01 October). [Link](#)

Tropical Biology Association -- Small Grants for African Conservation. The TBA offers annual small grants for conservation projects and research in Sub-Saharan Africa. The call is restricted to TBA alumni groups. Grants are for a maximum of £1,500. The application deadline is 30 April of each year. [Link](#)

Patagonia Environmental Grants Program. Patagonia makes grants to support grassroots organizations for campaigns to preserve and protect the environment. Thematic areas are alternative energy, biodiversity, forests, sustainable agriculture, water/marine issues, and others. Eligible countries include Argentina and Chile. Most grants are in the range of US\$3 thousand to US\$8 thousand. Proposals are submitted through Patagonia's retail stores at any time of the year, or by postal mail to the Environmental Grants Manager before 30 April and 31 August of each year. [Link](#)

PARC Alison Haskell Award for Excellence in Herpetofaunal Conservation -Request for Nominations!

PARC is seeking nominations for the 2012 recipient of our annual award in memory of our first PARC Federal Agencies Coordinator, Alison Haskell (1956 - 2006). The Alison Haskell Award for Excellence in Herpetofaunal Conservation is to recognize an individual in North America who exemplifies extraordinary commitment to herpetofaunal conservation, as did Alison, and is an "unsung hero," as Alison was. The award confers a cash prize (\$1000) and a commemorative plaque.

Alison's tenure with PARC was tragically shortened due to a valiant, but unsuccessful battle with ovarian cancer. Members of PARC aim to keep her memory alive through this annual award.

Nominations are due December 1, 2011. To read more about the award, how to nominate, and about Alison, [click here](http://parcplace.org/news-a-events/haskell-award.html) or visit <http://parcplace.org/news-a-events/haskell-award.html>.



Instructions to Authors

FrogLog publishes a range of articles on any research, discoveries or conservation news relating to amphibians. We encourage authors describing original research to first make submissions to a refereed journal and then, if appropriate, to publish a synopsis in FrogLog. Submissions to FrogLog should be in English, in the region of 1000 words, unless previously discussed with the editorial team, and follow the format of FrogLog 83 and above.

All graphics supplied for publishing should be submitted as separate files, ideally in original jpg format or alternative commonly used graphical format. Please ensure that the highest quality image is sent to allow for optimal reproduction.

Tables and charts may be included at the end of a word document with clear indication as to the appropriate title/legend.

All titles and legends should be listed one after the other, as part of the text document, separate from the figure files. Please do not write a legend below each figure.

Submission must include all authors first and surname which will be printed at the beginning of the published document.

Each submission will be referenced as follows at the back of the edition:

Tingley, R., Phillips, B. L. & Shine, R. (2011) Alien amphibians challenge Darwin's naturalization hypothesis. *FrogLog* 95. Author Contact: reid.tingley@gmail.com.

If you require further information on author affiliations, provide directly under this reference.

Examples of submissions can be found in previous editions of FrogLog and include:

- News and Comments
- Correspondence

- Obituaries
- Opinion
- Futures
- News & Views
- Insights, Reviews and Perspectives
- Upcoming meetings
- Recent Publications
- Books Releases
- Careers

Submission should be sent to froglog@amphibians.org.

Please name all files as follows, first author surname_brief title description_content i.e. tingle_darwins_naturalization_paper, tingle_darwins_naturalization_figure 1.

Students


The ASG has a particular interest in highlighting the vast amount of work being undertaken by students around the world and we invite students to submit synopsis of their thesis where appropriate.

Coming up in FrogLog Vol. 100

South America

Regional
Updates

100 editions of
FrogLog
and still going
strong

A close-up photograph of a brown frog with a textured, bumpy skin. The frog is perched on the edge of a large, reddish-brown leaf. The frog's eyes are prominent, and its mouth is slightly open. The background is dark, making the frog and the leaf stand out.

South America
Recent Publications
Grants
and much more.....

January 2012