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Species on the bottom of front cover: *Dyscophus antongilii* © F. Andreone

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A Conservation Strategy for the Amphibians of Madagascar 2

Centre ValBio

Parc National de Ranomafana, Madagascar

18-22 November 2014

supporting people and organizations

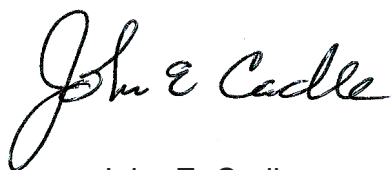


Becca Wier, Erik Ohlson, Hugh Barry Ferguson, Nicole Chaney and Rebecca Stobbart

foreword

Centre ValBio hosted its second international conference, A Conservation Strategy for the Amphibians of Madagascar (ACSAM2), from 17-22 November (ACSAM1 was held in 2006 in Antananarivo). Seventy-two amphibian biologists and conservationists from ten countries assembled at Centre ValBio to assess the current conservation status of Madagascar's amphibian fauna. Representatives of all major NGOs concerned with amphibian conservation in Madagascar attended, as did the Director General of the Madagascar Ministry of Water and Forests, the Director of Ranomafana National Park, and representatives of the IUCN, AmphibianArk, Durrell Wildlife Conservation Trust, Madagascar Faunal Group, Vahatra, Mitsinjo, and other conservation organizations. Eileen Larney and John Cadle of CVB served on the local organizing committee. The meeting was timely because in 2014 two discoveries that could have a major impact on amphibian populations in Madagascar were made: the presence of the amphibian pathogen *Batrachochytrium* (chytrid fungus) was confirmed in Madagascar, and populations of a highly invasive Asian toad (*Duttaphryne melanostictus*) were discovered near Toamasina on Madagascar's east coast. These are potentially grave threats to Madagascar's frog fauna and the toad is a potential threat to many other parts of the native fauna.

Participants at ACSAM2 had lively discussions on topics of direct import to developing a conservation strategy for Madagascar's frog fauna: species status in the wild, mitigation efforts, disease ecology, captive breeding potential, and the impact of invasive species. By late December 2014 a draft action plan had been circulated for comment and revision. The action plan targeted specific goals and timetables centered on seven major areas relevant to conservation efforts: (1) coordination of research and conservation activities; (2) development of standardized population monitoring programs across Madagascar; (3) basic research on emerging amphibian diseases in Madagascar and mitigation possibilities; (4) basic research on climate change effects; (5) management of focal amphibian sites for conservation; (6) assessment of harvesting and trade of amphibians; (7) captive breeding and zoo actions. Ranomafana National Park, with the highest known species diversity of amphibians in Madagascar (about 129 species), was a focus of much attention as the protected area with greatest species diversity and greatest capacity to quickly implement monitoring and research efforts. Centre ValBio is poised to lead in these efforts for amphibian conservation.



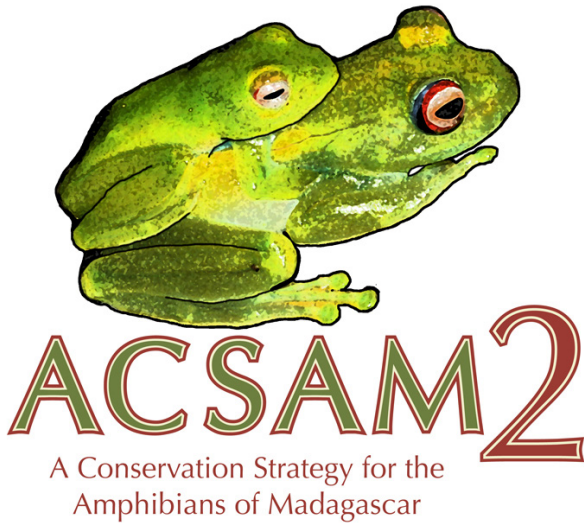
John E. Cadle

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Founder and Executive Director
Centre ValBio



Gathering people to
conserve the unique
frogs of Madagascar

ABSTRACTS

Centre ValBio

Parc National de Ranomafana, Madagascar

18-22 November 2014



Group photo of ACSAM2 attendees. © J.E. Cadle

A 8-YEARS FROG-JUMP TO BOOST AMPHIBIAN CONSERVATION IN MADAGASCAR AND TO RELY TWO ACSAM EDITIONS

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The conservation of Madagascar amphibians has become object of study and application in the last twenty years, and concomitant to the presence and action of several herpetologists, who take this discipline to Madagascar, and highlighted the importance of preparing a serious action plan. Until then, taxonomy and survey works were the main activities of former researchers. On the other hand, the presence of a handful number of passionate people accelerated and highlighted the relevance of conservation biology applied to Malagasy frogs. This novel activity has been marked by the activity of the IUCN Amphibian Specialist Group (ASG) - Madagascar, and by the launch of ACSAM (A Conservation Strategy for the Amphibians of Madagascar) Initiative. The first ACSAM meeting was held in Antananarivo in 2006, and allowed to boost all the consequent actions, finalised to amphibian conservation. Among these we mention the inclusion within IUCN Red List of all the species present at that time, and subsequent updates, the realisation of scientific and popular publications, the elaboration of the “Sahonagasy Action Plan”, and the chytrid monitoring through the CEC (Chytrid Emergency Cell) and the site-based action like New Protected Area Ankaratra. All this made of Madagascar an important place at world level for amphibian conservation. Due to the fact that the high species number (estimated in at least 500) and their endemism, coped with crucial threats (including chytrid, deforestation, pet-trade, food exploitation, alien species introduction) makes of this country an important place where to develop innovative strategies for amphibian conservation. The realisation of the new ACSAM meeting is an evidence of the fact that the union of foreign and Malagasy herpetologists has led to an important improvement in efficient initiatives. Much remains to be done, of course. The main thing is convincing Malagasy people (including politics) that protecting frogs is important in a country where conservation action can improve livelihood of the people around the amphibian site and an obvious priority and international community that a long-term project is necessary to safeguard one of the world biodiversity jewel.

ASG, ASA IN THE WORLD AND IN MADAGASCAR

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Finding solutions to counter amphibian declines and extinctions is one of the greatest conservation challenges of the century. The Amphibian Survival Alliance (ASA) protects amphibians and their habitats through dynamic partnerships worldwide and is taking the lead on finding partners to implement the ACAP priorities. With a membership of over 500 of the world's leading amphibians experts, the IUCN SSC Amphibian Specialist Group (ASG) is uniquely positioned to identify the current challenges to amphibian conservation and to recommend potential solutions. In mid-2013 the ASG established itself as the Scientific Advisory Board to the Amphibian Survival Alliance and initiated a number of thematic working groups designed to review efforts since the publication of the ACAP in 2006. Each thematic working group maintains a web page (hosted on amphibians.org) aimed at sharing information and encouraging conservation action, which evolves as knowledge increases and progress is made. Using this as a basis for discussion the ASA developed a clear strategy that prioritizes and translates the science into specific conservation actions and drives their implementation to address amphibian conservation challenges worldwide. As Madagascar is one of the World's amphibian diversity hotspots and has recently had two potentially catastrophic threats identified (the amphibian chytrid fungus and the Asian toad, *Duttaphrynus melanostictus*), it has become an important area of concern for the ASA and the global amphibian conservation community. In recognition of the significance of the potential threats, the ASA raised funds to support the following elements of the emergency and long-term response to safeguard Madagascar's frog species: Developing and testing effective probiotic therapy for target species; Chytrid monitoring and strain identification; Habitat protection; and, A new Amphibian Conservation Strategy for the Amphibians of Madagascar (ACSAM2).

REBIOMA DATA PORTAL, TOOL FOR CONSERVATION PLANNING IN MADAGASCAR

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Madagascar is data rich, but data access is poor. Biodiversity data are integral to conservation, monitoring, and protected area establishment, but only if data are available, sufficiently accurate, and provided in a manner that accounts for Madagascar's high rate of species discovery and taxonomic change. REBIOMA provides freely accessible high quality data in an online system designed to meet these challenges.

The mission of the REBIOMA data portal is to serve quality-labeled, up-to-date species occurrence data and environmental niche models for Madagascar's flora and fauna, on both marine and terrestrial domain. REBIOMA serves species occurrence data for marine and terrestrial of Madagascar. Following data upload, data is automatically validated against a Madagascar geographic extent and a taxonomic authority. At upload, data providers can decide whether their data will be public, private, and they can also make it private but shared only with selected collaborators.

We build a way for data reviewers to add quality labels to individual data records, allowing selection of data for modeling and conservation assessments according to quality. Data users can query data in numerous ways by using the simple or advanced search. REBIOMA also serves environmental niche models for current and future climate scenarios for terrestrial species.

One of the key features of the REBIOMA web portal is its support of species distribution models, created from taxonomically valid and quality reviewed public and private occurrences data.

Species distribution models are produced for species for which there are at least eight, reliably reviewed, non-duplicate (per grid cell) records. The MaxEnt (Maximum Entropy) software is used to produce continuous distribution models from these occurrence records and environmental data for several eras: current (2000), and future (2080). The result is generally interpreted as a prediction of habitat suitability. Each model results are available on the portal and ready for download as ascii and .html files.

The Maxent software provided through a series of algorithms, a probability of occurrence of a species based on environmental layers data. The modeling results provide an estimate of the probability of occurrence of a species and a measure of the influence of each environmental factor took into account. These results can be presented in map form.

REBIOMA presentation during the ACSAM2 will therefore focus on this data portal online (<http://data.rebioma.net>) and the products provided for biodiversity conservation planning in Madagascar. We will present the case of *Boophis madagascariensis*.

HOW TO IMPROVE THE DATA QUALITY IN AMPHIBIAN DISTRIBUTION RESEARCH

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Publications of herpetological surveys are of crucial importance for understanding both the distribution and the conservation status of Malagasy amphibian species. However, the reliable identification of amphibians is often challenging. Numerous new and often cryptic species have been described over the past 20 years, and taxonomical concepts have changed continuously. Thus it is not surprising that many published species records are incorrect and questionable records cannot be verified. What can scientists do to make their data more reliable and useful? When specimens have been collected, publications of distributional data should give exact reference to at least one voucher specimen of each recorded species and locality. If possible, adult males are preferred as reference specimens rather than females and juveniles, which are more difficult to identify. The optimal voucher is a male with an associated tissue sample for future molecular re-identification, color photographs of the live individual, and recorded vocalizations. If voucher specimens are not available, voucher photographs of living frogs are the best alternative. They should be published together with the survey data or be stored in public databases (e.g., by using the Sahonagasy website). The publication of information on voucher specimens (even without additional data such as photos, tissue samples, or call recordings) makes revisionary work much easier. Such work, along with further surveys, is urgently needed to provide decision makers and conservationists with reliable data for the implementation of effective conservation measures.

BIG BROTHER IS WATCHING YOU: RADIO-TRACKING AS A CONSERVATION RESEARCH TOOL FOR AMPHIBIANS IN MADAGASCAR

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Radio-telemetry is an important tool widely used on vertebrates to aid the understanding of movements and determine home ranges. Such data enables scientists to accurately study the habitat use and development of management plans for conservation. There have been huge improvements in the devices available in the market. However, trial studies are still an essential part of radio-tracking relatively unstudied species in order to better choose the appropriate methods of attaching transmitters.

We present here the first two cases of amphibian radio-tracking in Madagascar and discuss the advantages and disadvantages of the two devices applied. In the first case we used intraperitoneal implantation of the transmitters in the tomato frog *Dyscophus antongillii*, and for the second study we used externally affixed transmitters in the rainbow frog *Scaphiophryne gottlebei*. These are two endangered species sharing several threats to their conservation and are both listed on CITES for the value on the pet trade.

Once common, the tomato frog population in Maroantsetra appears to become rarer due to the growing urbanisation. Our trial study aimed to understand how the individuals used the habitat within a non-protected urban area.

A single haplotype is dominant in all populations of *S. gottlebei* across the largest part of its range, with this being a clear indication of a good dispersal capacity, and thus a consequent high gene flow between the populations. However, the habitat specialization and cryptic life observed in *S. gottlebei* apparently contradict the idea of a mobile species. Our study results confirmed that individuals of this species are quite phylopatric to the canyons they inhabit. The observed generalized haplotype sharing might then be explained by passive dispersal of larvae and metamorphosed individuals during the intense cyclonic floods.

Overall, none of the techniques used is perfect and both present disadvantages, may affect individual movements or even increase the likelihood of mortality. Nonetheless, the data generated are of great value and can certainly contribute for a better management of wild amphibian populations.

INVOLVING LOCAL PEOPLE TO THE CONSERVATION OF AMPHIBIANS IN SAHAMALAZA - NOSY RADAMA NATIONAL PARK

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Located in the north west of Madagascar, the Sahamalaza - Nosy Radama National Park is well renowned for its biodiversity. With more than 15 amphibian species, the park shelters four endemics, including *Cophyla berara*, *Boophis jaegeri*, *Boophis tsilomaro* and the newly described *Boophis ankarafensis* which is found nowhere else in the country. Because of its high species richness and the constant pressure from human activities, Nosy Radama National Park can be considered as a hotspot for conservation priorities. Understanding the local communities is a key component for successful biodiversity conservation and natural resources management. We base our activities on strengthening local knowledge and on raising initiative and responsibility for a long term conservation. Since 2013, conservation activities were conducted at the Sahamalaza peninsula. These activities include research, local capacity building and environmental education. As part of research activities, we undertook a biological assessment in Anabohazo forest (Nosy Radama National Park), during which local park managers were trained to locate amphibians and monitor the population for a comprehensive data collection. To raise people awareness on Biodiversity value, we disseminate research results through video projection sessions and meetings in surrounding villages. Also, for a long term conservation, we implement an environmental education program at elementary schools to raise the value of indigenous biodiversity and to inculcate different alternatives for living, using the natural resources wisely, for future generation.

ARE THERE ENOUGH EDUCATION EFFORTS TO PROMOTE AMPHIBIAN CONSERVATION IN MADAGASCAR?

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Environmental Education (EE) refers to organized efforts to teach about how natural environments function and particularly, how human beings can manage their behavior and ecosystems in order to live sustainably'. In the view of current degradation rates in Madagascar, EE efforts should be a priority action for biodiversity conservation. How to run EE? On 31 October 2014 I made a Google search for 'Environmental+education' obtaining 115,000,000 articles. Only 462,000 articles came out when I added Amphibians in contrast to 1,630,000 for Reptiles, 6,520,000 for Mammals, 40,300,000 for birds and 71,000,000 fishes. Results were similar when using Google Scholar: 3,000,000 articles came out when searching for EE only. This number decreased to 27,300 when Amphibians was added, 36,200 with reptiles, 180,000 with Mammals, 221,000 with birds and 143,000 with Fishes. When Madagascar was added to EE, I found 38,700 articles, reduced to 4,290 articles only when treating Amphibians, 7,640 for Reptiles, 12,200 with Mammals, 17,700 for birds and 17,300 for fishes. The environmental education efforts carried out for amphibians in Madagascar is perhaps proportional to what is currently known about our species, however, they might be much lower than the biodiversity degradation rates. Increased efforts are needed.

AMANAGEMENT OF HABITATS FOR CONSERVATION, SEARCH RESULTS AND FUTURE'S THREATS IN THE PROTECTED FOREST OF AMBODIRIANA

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Due to abiotic conditions as climate, landform and hydrology, the protected forest of Ambodiriana includes all habitats preferred by amphibians.

Studies have shown special richness in amphibians, some species clearly identified, some doubtful some probably news. But since 2011 no study DNA code or acoustics were conducted.

Currently habitat protection is done in collaboration with two local associations using compensation contracts through ecotourism. But due to the European crisis, ecotourism and private funds are decreasing.

Currently ADEFA wants to withdraw from management and search for a strong organization to continue this conservation project. Without a radical change in the actual governance, the risk of seeing these habitats disappear in the near future is high.

EFFECTS OF ANTHROPOGENIC HABITAT FRAGMENTATION ON DIFFERENT ASPECTS OF AMPHIBIAN DIVERSITY IN RANOMAFANA RAINFOREST, MADAGASCAR

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Madagascar's ecosystems are severely influenced by anthropogenic habitat alterations such as deforestation, degradation and fragmentation. Although in general these disturbances of natural ecosystems are thought to have negative effects on biodiversity, there is no consistent pattern on species' and communities' reactions. Undisturbed forests outside protected areas are declining rapidly and today's protected areas might not be sufficient to protect all extant species in the long-term. For conservation planning it is hence important to understand fragmentation effects on biodiversity and assess the diversity and conservation value of disturbed habitats.

In a three-year study we determined different aspects of amphibian diversity along streams and in terrestrial forest parts, and analyzed differences on a gradient of three habitat types: continuous forest (i.e., Ranomafana National Park), forest fragments, and matrix (secondary vegetation, banana plantations, rice fields). In general, fragmentation effects on diversity were weak, i.e. there were no differences in species richness between continuous forest and fragments, but differences in species composition. This indicates that fragments represent suitable habitat for amphibians. Species richness and composition in the matrix varied highly between different matrix types. Streams in the matrix and banana plantations harboured as many species as continuous forest and fragments, indicating that even highly altered habitats can act as vital corridors and/or habitats for many species if at least some habitat structures such as small gallery forests along streams are maintained. However, diversity in secondary vegetation and rice fields was significantly reduced.

We conclude that forest fragments and even some matrix habitats outside protected areas are important refuges of amphibian diversity in Madagascar, and should be included to a greater extent in conservation planning. We discuss the exposure to high natural disturbances (e.g., cyclones) as a factor that predisposes the exceptional resilience of Madagascan amphibians to anthropogenic disturbances.

CONSERVATION EFFORTS FOR THE ENDANGERED AMPHIBIAN SPECIES OF THE ANKARATRA MASSIF

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The Ankaratra massif contains two critically endangered species confined to the high mountain *Boophis williamsi* and *Mantidactylus pauliani* with a restricted distribution range. Three years' surveys were performed between 2011 and 2013 after the moment where the entire habitats were burnt in October 2010. During the surveys, the populations show an oscillation which dropped in 2012 to increase in 2013 from when no considerable threat happened again to the habitat.

This conservation effort could not be effective without the help of the local based communities that understand the importance of the biodiversity and the ecosystem services. This aim were possible when applying the IUCN policy for the creation of New protected Areas in Madagascar and Ankaratra is one at the advanced stage for the process during the three years project and actually, the definitive protection will be obtained very soon.

But still, the efforts should be continued to allow a sustainable conservation and development seeing that the poverty of the local populations has a very bad impact on the biodiversity and ecosystem in Madagascar. This communication will relate the main results of our efforts for the conservation of these species, the ecosystem and for local based community sustainable development.

UNE NOUVELLE AIRE PROTEGEE POUR LA CONSERVATION DE LA MANTELLE DOREE *MANTELLA AURANTIACA*

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A l'issue de l'ACSAM 1, une stratégie pour la conservation de l'amphibien En Danger Critique d'extinction *Mantella aurantiaca* a été développée. Cette stratégie a défini les objectifs principaux et les actions à mettre en œuvre pour la période 2011 – 2015. Parmi les priorités : protéger les marais de pont de *Mantella aurantiaca* se trouvant au sud de la ville de Moramanga par la création d'une Nouvelle Aire Protégée. En collaboration avec le Ministère de l'Environnement, de l'Ecologie et des Forêts ainsi que les autorités et communautés locales, Madagasikara Voakajy a relevé ce défi. Les consultations à différents niveaux (villages, Fokontany, Communes, District et Région) ainsi que les recherches sur la distribution de l'espèce et les enquêtes socio-économiques ont permis d'établir le Plan d'Aménagement et de Gestion de la Nouvelle Aire Protégée Mangabe-Ranomana-Sasarotra. Avec une surface totale de 27 132ha, cette NAP est subdivisée en zone de conservation stricte (6 734ha), zone d'utilisation contrôlée (5 473ha) et zone d'utilisation durable (15 138ha). Les actions de recherche, sensibilisation, appuis et répression menées jusqu'à ce jour semblent réduire les pressions sur les mantelles dorées et leurs habitats. Cependant, de grands défis restent à relever : arrêter l'exploitation aurifère illégale, stopper la pratique du tavy, favoriser l'exploitation durable de l'espèce et améliorer les conditions et capacités de conservation de la NAP au niveau local.

MADAGASCAR FAUNA AND FLORA GROUP'S AMPHIBIAN CONSERVATION RESEARCH IN THE ATSINANANA REGION, EASTERN MADAGASCAR

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Madagascar Fauna and Flora Group (MFG) oversee a diverse array of amphibian conservation research at its two sites of Betampona Strict Nature Reserve and Parc Ivoloïna near Toamasina, east coast of Madagascar. MFG has been conducting amphibian monitoring on distance-sampling transects in Betampona since Oct 2007 (with simple counts going back to Feb 2004). In addition daily meteorological data on rainfall and maximum/minimum temperatures has been collected at the reserve from Aug 1997 allowing investigation into the impact of climatic variation on amphibian populations. Monitoring of amphibian populations was increased in July 2009 when further transects were set up at two amphibian-rich sites within the reserve. Preliminary data shows marked differences in species assemblages and annual activity patterns between the two sites reinforcing the need for research at multiple locations and throughout the year to fully understand population dynamics in a given protected area. Efforts began in Jan 2014 to start mapping species distributions of the 79 listed taxa across Betampona to gain a deeper understanding of habitat specificity, particularly for the 24 Betampona micro-endemic species. Information will be uploaded to a geo-database for the reserve, which already includes detailed land cover maps to identify hotspots for amphibian conservation, assess the impact of invasive plants on amphibian assemblages and to develop sound conservation management strategies for the future.

In Parc Ivoloïna annual inventories of amphibian species were carried out from 2008 to 2013 and a partial genetic survey was completed in 2010 giving a combined list of 36 taxa for the Parc. Twice-annual screening for *Bd* has been carried out at the Parc since Feb 2011 (all samples so far testing negative) and plans are now underway to develop a husbandry training and research unit to develop husbandry protocols for locally-occurring species, many of which have not yet been kept in captivity.

THE PROGRESSES DONE DURING THE ACSAM1 REALIZATION

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From the ACSAM 1 held in 2006, a planning program was built up and officially launched in 2008 under a booklet entitled Sahonagasy Action Plan.

It contains eight strategic axes for which the progress within the last eight years will be treated in this communication. Of which, we can see the Coordination of Research and conservation activities, the monitoring of the Amphibians in Madagascar, the management of the emerging diseases, the climate change and the Amphibians, the management of focal Amphibian sites for conservation, the harvest and trade of Amphibians, the captive breeding and zoo actions and the development of an unified herpetological collection.

REDLIST AND MADAGASCAR: AN OVERVIEW OF ASSESSMENT HISTORY

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Established in 2009, the SSC Amphibian Red List Authority (Amphibian RLA) maintains and builds on the work of the Global Amphibian Assessment (GAA) by assessing the newly described species and also updating existing assessments as new information becomes available. The role of the SSC Red List Authorities is to ensure that all species within their jurisdiction are correctly assessed against the IUCN Red List Categories and Criteria at least once every ten years and, if possible, every five years. The Amphibian RLA Membership is organized into Regional or National Working Groups comprised of Tier I and II Members; all RLA Members are also members of the IUCN SSC Amphibian Specialist Group (ASG).

The Madagascar National Working Group is led by Tier I Member, Franco Andreone, and assisted by Tier II Members, Andolalao Rakotoarison, Neil D'Cruze, and Steve Megson. They ensure the 247 Malagasy amphibian species assessments on the Red List are up-to-date and accurately attributed one of the 9 IUCN Red List categories: Critically Endangered (n=8), Endangered (n=29), Vulnerable (n=32), Near Threatened (n=17), Least Concern (n=108), Data Deficient (n=53). Of the currently assessed species, 218 (or 88%) were last assessed in 2004 during the GAA and urgently require reassessment. An additional 62 newly described species have been identified this year as needing assessment for the first time.

Workshops have been organized to run in parallel to the ACSAM2 meeting and will focus on assessing the 62 newly described species, along with those species requiring reassessment because one of the new species is the result of a taxonomic split (n=9). Also being reassessed are the 53 Data Deficient species on the Red List. A subset of these have been identified as having new information and thus may result in being attributed a new IUCN Red List category. The expected output of these workshops is fully updated assessments for all Data Deficient species and new assessments for all recently described species. Post-workshop follow ups will be undertaken by Jennifer Luedtke and Amphibian RLA intern Lucy Coals in view of publishing these assessments in the first 2015 IUCN Red List Update.

AN OVERVIEW ON ACTIONS TAKEN REGARDING THE INVASIVE TOAD, *DUTTAPHRYNUS MELANOSTICTUS*, IN THE TOAMASINA AREA SINCE MARCH 2014

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In March 2014, the scientific and conservation communities were alerted to the presence of an invasive toad, *Duttaphrynus melanostictus*, causing widespread concern about the potential impact on Madagascar's native biodiversity. In April 2014, a press conference was held, coinciding with a number of meetings by local, regional, and national government officials, as well as concerned NGOs involved in areas of conservation and personnel from the Ambatovy mine. Soon international invasive species experts were brought into the discussion through email, and the outlines of a plan developed. Most pressing was to determine the real distribution of the toad and to delineate its boundaries. The Madagascar Fauna and Flora Group (MFG), based in Toamasina, was nominated to coordinate this initial effort at the meeting held on April 24, 2014 by the Secrétaire Générale of Region Atsinanana, representatives from the Ministry of Environment, Ecology and Forestry and members of the Amphibian Specialist Group (ASG) of Madagascar. For additional manpower and logistical assistance Association Mitsinjo and the Institut Supérieur des Sciences Environnemental et Développement Durable (ISSEDD), volunteered their support. In total we completed 165 visual encounter surveys and detected the toad at 68 sites, estimating its minimum area of incursion in November 2014 as 122 km². This data will help assess the feasibility of eradication as the project moves forward.

THE EVOLUTIONARY ECOLOGY OF *BATRACHOCHYTRIUM* SP.

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Amphibian-parasitising chytrid fungi are widely emerging as a threat to amphibian biodiversity worldwide. However, whether an amphibian wins, or loses, the fight against a chytrid assault is highly dependent on context. I will examine the major factors that determine the outcome of the amphibian/chytrid interaction using data from the *Bd* Global Mapping project, and from a long-term study in the European Pyrenees mountains. I will then summarise what we know about the molecular epidemiology of *Batrachochytrium* throughout Africa, and how this information can then be used to inform conservation strategies in Madagascar.

MITIGATION STRATEGIES FOR DISEASES THAT POSE A THREAT TO THE AMPHIBIANS OF MADAGASCAR

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Chytridiomycosis, caused by the lethal fungal pathogen *Batrachochytrium dendrobatidis* (*Bd*), is associated with massive population declines and extinctions around the world. This pathogen poses a threat to the hyper-diverse and endemic amphibian fauna of Madagascar. There are at least eight mitigation strategies that have been used or proposed that can mitigate the negative effects of chytridiomycosis, which include manipulations of amphibians' defenses and manipulations of the ecosystem. Some of these strategies are vaccination, probiotic bioaugmentation, selective breeding, assurance colonies, head starting, habitat alteration and manipulation of free-living aquatic organisms that prey on *Bd*. To date, probiotic bioaugmentation with locally-occurring anti-*Bd* bacteria is the only strategy that has been experimentally tested in the field, and the results showed that bioaugmentation led to much higher survival in a population of frogs invaded by a virulent strain of *Bd*. A project led by co-author M. Bletz is underway in Madagascar to determine effective probiotic candidates for Malagasy frogs. Other mitigation strategies show promise based on laboratory experiments or field surveys. Assurance colonies are critical until flexible and effective mitigation strategies are available. Progress is being made in understanding the microbiome of amphibian skins, amphibian immunology and in understanding the genomic variation, biology and transmission of *Bd*, all of which will be helpful in designing mitigation strategies. In addition, other disease agents such as ranaviruses need to be considered, especially in the context of co-infection with *Bd*. It is likely that a combination of strategies will be most effective in mitigating the negative effects of *Bd* in Madagascar.

CAPTIVE BREEDING PROGRAMS TO MITIGATE BD-RELATED EXTINCTIONS: LESSONS FROM PANAMA

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In 2008, we established the Panama Amphibian Rescue and Conservation Project in response to the dramatic chytridiomycosis-related declines of amphibians observed in Panama. The project was initially funded by a consortium of 6 zoo and conservation non-profits developed a strategy to build capacity in Panama to conserve at-risk species. We achieved our primary goal, which was to build 500m² of biosecure space in Panama to hold ex-situ populations of endangered frogs, and to secure funding and training opportunities to hire 10 staff to run the project in-country. We successfully established ex-situ colonies of 12 species of endangered frogs. In the process, we learned that the probability of avoiding extinction through captive breeding efforts = probability finding a sufficient founding population x probability we can breed them successfully in captivity x probability they go extinct in the wild. The chance of establishing a founding population is increased by collecting founding animals prior to Bd-related declines and by having knowledge of their natural history, particularly of rare species. Prior breeding and husbandry experience with the species, or a close surrogate increases the chances of successfully breeding the species in captivity. Prior knowledge of a species susceptibility to Bd improves our ability to predict the chance of extinction. Captive colonies alone do not mitigate the threat of *Bd*. As such, we support ongoing research using Panamanian golden frogs in the US managed by the Golden Frog SSP to investigate potential tools that would allow us to reintroduce frogs back into the wild. To date our research has focused on probiotics and transcriptome studies and we have recently completed construction of a new amphibian research laboratory to continue to pursue and facilitate further mitigation research in Panama. Finally, we built public support in Panama for amphibian conservation through 2 public exhibitions of amphibians, coordinating annual golden frog day celebrations attended by 2,000 people, and developed informal educational activities linked both to the Panamanian school curriculum and our exhibits.

THE DISEASE DETECTION AND MITIGATION IN MADAGASCAR

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During the implementation of the program of disease detection and mitigation that were mentioned into the ACSAM 1, the Chytrid Emergency Cell was set up in 2011 to coordinate and orient the policy of Madagascar in term of the emerging disease for the Amphibians.

As the chytrid was not detected for the eight years before, extensive research has been set up for the last three years. These are done with the collaboration of the National NGOs for 8 sites. Some collaborations have been concluded for the mitigation of the disease, if it is confirmed to be in Madagascar as well.

The CEC facilitates all the responses about any cases of massive death detections and collaborates with the universities in and out of the country as well. The development in time of an actual policy to permit Madagascar to have more chance to preserve its exceptional Amphibians is desirable, so an action plan should be developed during this ACSAM meeting.

PROBIOTIC CONSERVATION STRATEGIES FOR MADAGASCAR: PROGRESS REPORT

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Defensive skin microbes are an important line of defense for amphibians against the pathogenic fungus, *Batrachochytrium dendrobatidis*, and have been successfully manipulated to mitigate the disease, chytridiomycosis. We devised a six-phase filtering protocol to identify effective probiotics for threatened amphibians around the world, including Madagascar, in effort to provide a conservation mechanism that will allow amphibians to persist in the wild despite the presence of a lethal genotype of *Bd*. In 2013, we began the implementation of this probiotic initiative in Madagascar. To date, we have sampled over 1000 individuals of 120 species at 15 different locations across Madagascar (Phase 1). From these samples, we have isolated 3,506 bacterial isolates, most of which have been successfully challenged against the chytrid fungus to determine if they inhibit the pathogen (Phase 2). We have found approximately 520 isolates from a range of frog species and locations that can inhibit the growth of *Bd* by more than 95%. These inhibitory bacteria are potential probiotics, and the next step is to determine which of these probiotic candidates can colonize and persist on the host amphibians (Phase 3). Probiotics will likely be part of an integrative approach to curb the detrimental effects of chytridiomycosis, and we plan to continue working through the phases of the filtering protocol to determine which bacterial isolates will effectively control the pathogen on Malagasy frogs.

EFFICACY OF THE F10 AGAINST AMPHIBIAN CHYTRID FUNGUS

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Infectious and transmittable diseases, such as chytridiomycosis, which is caused by the emerging pathogen *Batrachochytrium dendrobatidis*, has been identified as one of the most important drivers of amphibian declines and extinction. A need therefore exists for effective treatment of chytridiomycosis, especially in *ex situ* breeding programs for endangered species. F10 (Health and Hygiene) is a veterinary disinfectant that has been shown to be 100% effective in killing chytrid cultures *in vitro*. Our objective was to test the efficacy of F10 against *B. dendrobatidis* across different life stages of Guttural toads. F10 is able to kill *Bd* even at very low concentrations such as 1:30,000 and only takes 5 min or less at concentrations of 1:5,000 and stronger. Tadpoles survive a 1:10,000 concentration for 30 min. We achieved an almost 90% clearance of *Bd* using this protocol. We conclude that a 100% success rate was not achieved because of dose frequency limitation, and suggest that more than five doses are required to achieve 100% clearance.

CHYTRID AND THE MOUNTAIN CHICKEN (*LEPTODACTYLUS FALLAX*) IN MONTSERRAT, CARIBBEAN

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The Critically Endangered mountain chicken (*Leptodactylus fallax*) is endemic to the islands of Montserrat and Dominica in the Caribbean. Its population crashed by over 90% in less than two years on both islands following the arrival of chytrid (*Bd*) in the early 2000's in Dominica and 2009 in Montserrat. As regular population monitoring had been conducted on Montserrat before and after the arrival of *Bd* this represents one of best documented declines in a species due to *Bd* globally. To save the species Durrell led an emergency evacuation of 50 frogs from Montserrat to Jersey in 2009 and initiated a captive breeding programme in three European zoos. Field research has subsequently been carried out: first with a series of itraconazole trials in Montserrat to examine the efficacy of using this as a treatment and second, studying the disease dynamics of *Bd* in the wild through a series of experimental releases. The itraconazole trials showed that it increased survival probability and lifespan in frogs but only whilst treatment continued with all long-term benefits lost once treatment ceased. The experimental release study, although not yet complete shows that mountain chickens disperse more in the wet season than in the dry season and early indications suggest they suffer fewer deaths during the wet season than the dry. Parallel monitoring of *Bd* in sympatric amphibian species on Montserrat shows a high degree of seasonality in *Bd*, with prevalence much greater during the drier periods - a possible reason for the apparent fewer deaths during the wet season. This information is being used to help guide and develop future management options for the species across its range as part of a long-term recovery plan, including the establishment of a semi-wild managed population in Montserrat.

CAPTIVE BREEDING AND *EX SITU* CONSERVATION OF MALAGASY AMPHIBIANS

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The proportion of Malagasy amphibian species maintained by zoological institutions outside Madagascar represents a small fraction of the diversity the island supports. This poses a challenge on how should we prioritize the selection of species and their future arrival to improve the captive husbandry of this species region. We used ZIMS, a zoological database for zoo and aquarium collections, to survey what taxa were represented internationally and found that the number of species being maintained in 2014 was slightly increased in diversity of species and with certain regularity of breeding few species compared with the analysis of 2007 following the first ACSAM. In parallel, a significant progress has been achieved since the first conference has been made within Madagascar at Andasibe where a biosecure facility specifically for the captive breeding of amphibians was established by Association Mitsinjo, the Amphibian Specialist Group of Madagascar and the Direction Générale des Forêts. Here nine species have been kept, three bred to second or third generation, and one genetically viable captive assurance colony of the Critically Endangered frog *Mantella aurantiaca* established. We conclude by highlighting the need for a re-prioritization of *ex situ* action for Madagascar's amphibians and discuss some of the challenges breeding programs face, pointing out the importance of developing a coordinated programme for the captive colonies in and out of country as facilitating the process of acquiring the new species.

LESSONS LEARNED FROM DEVELOPING A SMALL AMPHIBIAN UNIT AT PARC IVOLOINA, TOAMASINA, MADAGASCAR

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In November 2012, two members from MFG's Parc Zoologique Ivoloina (Parc Ivoloina) attended an amphibian husbandry workshop held at Association Mitsinjo's facilities in Andasibe. Following this training, MFG was encouraged to apply for seed funding from Durrell to initiate a small amphibian husbandry program. Additional support was received from Unione Italiana degli Zoo e degli Acquari thanks to Franco Andreone. The initial structure was completed one year later, in November 2013, and 40 *Heteraxilus madagascariensis* were collected from the Parc Ivoloina forestry station. Following a visit by Devin Edmonds (Association Mitsinjo) in May 2014, MFG realized that certain improvements were necessary. Per Devin's recommendations, the initial population of frogs was released back into the wild. At the same time, MFG was awarded a grant from Amphibian Ark to improve the biosecurity of the unit. Renovations to the center began, including adding a separate coat room and quarantine room, installing a wastewater treatment system, and ensuring that the temperature in the unit was reduced. In July, an in-depth series of exchanges between Mitsinjo and Ivoloina was initiated (also financed by Durrell). At this point, the focus is to spend the next six months developing a population of insects for live food. After six months, MFG will re-evaluate its progress.

PROJECT OF GENETIC ASSESSMENT OF THE EUROPEAN CAPTIVE POPULATION OF *MANTELLA AURANTIACA*

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Mantella aurantiaca is an emblematic species among the amphibians of Madagascar. This active and highly coloured frog is greatly prized by hobbyists and zoos all around the world. IUCN has considered this species as Critically Endangered since 2004 and EDGE program lists this species at the 140th rank of the 4339 amphibian species considered as endangered. With 1448 individuals already listed in zoos in ZIMS database, zoological institutions have a great role to play in *ex situ* conservation of this species. Paignton zoo has led an historical study to identify the origin of the main lineages of *Mantella aurantiaca* in European zoos based on analysis of ZIMS database. They have identified 4 independent historical lineages. Nothing is known about genetic diversity and inbreeding in European captive population. At the end of 2014 will begin a DNA sampling campaign in various European zoological institutions in order to obtain data allowing to answer the following questions: (1) are the historical lineages identified by Paignton zoo supported by genetic data and can we link these lineages to wild population? (2) What is the genetic diversity of the captive populations compared to the wild populations? (3) Can we assess the inbreeding depression in the European captive population? The answer to these questions will help to better know the actual captive population and give some preconisation to improve the management of this species in captivity in an *ex-situ* conservation goal.



Felix Rakotondraparany
exposing his views about
amphibian conservation



Patricia Wright giving the
closing ceremony discourse



Brian Gratwicke, Patricia
Wright and Franco Andreone
at Centre ValBio

back cover photos

Platypelis cf. *pollicaris*

(top left) © F. Andreone

Boophis *tasymena*

(top right) © F. Andreone

Gephyromantis cf. *asper*

(middle left) © G. M. Rosa

Boophis *elenae*

(middle right) © F. Andreone

Aglyptodactylus *madagascariensis*

(bottom left) © G. M. Rosa



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