The Amphibians of the Sahamalaza Peninsula, Northwest Madagascar

Actions for their Conservation

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Cover photo: *Boophis ankarafensis* (Gonçalo M. Rosa).

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Foreword

The current mass extinction episode is most apparent in the amphibians. With over 7,400 species, amphibians are dependent on clean fresh water and damp habitats and many are very sensitive to changes in water or soil quality and the potential impacts of climate change. Additionally, many species are suffering from an epidemic involving a chytrid fungus. As amphibians are intimately associated with both terrestrial and aquatic habitats they are often regarded as indicators of the health of the environment. The latest figures show that there are nearly as many species of amphibians categorised as Threatened as those of Threatened birds and mammals put together, with an estimated 31-41%[1] of amphibian species in danger of extinction.

Madagascar is not immune to the amphibian extinction crisis, and due to its extremely high amphibian species richness and high levels of endemism, it can be regarded as one of the World's hotspots for amphibian species richness. Finding solutions to counter amphibian declines and extinctions is one of the greatest conservation challenges of the century, and the problems faced globally are well represented in Madagascar. This action plan identifies the general threats to the amphibians of Sahamalaza and recommends appropriate and achievable conservation actions. In addition, it focusses on a number of species-specific issues and discusses ways to improve their respective species' conservation status. This action plan serves as an exemplar, and if we could produce plans like this for all the amphibian hotspots then the future would look a lot brighter for amphibian survival.

The remarkable team that have collaborated to produce this conservation action plan for the Sahamalaza Peninsula amphibians are well known amphibian enthusiasts and conservationists, and good people like these are in short supply. Although after visiting Madagascar in 2014 I did not hold out a lot of hope for the future of Malagasy amphibians, action plans like this one clearly show the route to success, and combined with the passion and drive of the authors I now have hope for these amazing amphibians that are far too valuable to lose.

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[1] These numbers are based on the IUCN Red List, both including and excluding DD species from the count.

Outline

Amphibians are experiencing an unprecedented worldwide decline. Habitat destruction is one of the greatest contributory factors behind this decline. Madagascar supports incredibly high levels of amphibian diversity and endemism; however, high rates of deforestation threaten many of the habitats that these species rely upon. These threats extend to the Sahamalaza Peninsula in Northwest Madagascar, where forests are being cleared by slash-and-burn agriculture and small-scale logging. At least nineteen native amphibian species are known to occur from the peninsula, along with one non-native frog species (*Hoplobatrachus tigerinus*). Three of these species are thought to be locally endemic to the peninsula (*Cophyla berara, Boophis ankarafensis* and *Boophis tsilomaro*); this may also be the case for a further three species that still require additional investigations for description and characterisation (*Platypelis* sp. aff. *cowanii, Rhombophryne* sp. aff. *alluaudi* and *Stumpffia* sp. aff. *pygmaea*). Two species are classified as threatened; one of which is Critically Endangered (*C. berara*) and another Vulnerable (*Boophis jaegeri*). Six species have not been evaluated; two of which will most likely qualify as Critically Endangered (*B. ankarafensis* and *B. tsilomaro*), while four still require description before evaluation can occur. One species is Data Deficient but will most likely qualify as Least Concern (*B. brachychir*); the ten remaining native species are Least Concern. There must be an immediate cessation of forest destruction to prevent further population decline in the peninsula's highly threatened local endemics and other forest-dependent species. Necessary actions include improved community engagement and education, the establishment of a second research station, and the provision of sustainable means of employment and sustenance for local people. Research should be conducted into the feasibility of establishing a captive breeding colony for peninsula's locally endemic species to insure against possible future extinction events resulting from the destruction of natural habitats on the peninsula.

Glossary of Terms and Abbreviations

AEECL Association Européenne pour l'Etude et la Conservation des Lémuriens.

ASA Amphibian Survival Alliance.

ASG Amphibian Specialist Group.

BZS Bristol Zoological Society.

EAZA European Association of Zoos and Aquaria.

IUCN International Union for Conservation of Nature.

MBP Madagascar Biodiversity Partnership.

Red List The IUCN Red List of Threatened Species is an annually updated inventory of the extinction risk and global conservation status of plant and animal species.

Red List Categories The IUCN Red List Categories and Criteria are intended to be an easily and widely understood system for classifying species at high risk of global extinction. The general aim of the system is to provide an explicit, objective framework for the classification of the broadest range of species according to their extinction risk (IUCN, 2001).

> **Extinct (EX)** A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual.
>
> **Extinct in the Wild (EW)** A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual.
>
> **Critically Endangered (CR)** A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria For Critically Endangered, and it is therefore considered to be facing an extremely high risk of extinction in the wild.
>
> **Endangered (EN)** A taxon is Endangered when the best available evidence indicates that it meets any of the criteria for Endangered, and it is therefore considered to be facing a very high risk of extinction in the wild.
>
> **Vulnerable (VU)** A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria for Vulnerable, and it is therefore considered to be facing a high risk of extinction in the wild.

Near Threatened (NT) A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

Least Concern (LC) A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

Data Deficient (DD) A taxon is Data Deficient when there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat.

Not Evaluated (NE) A taxon is Not Evaluated when it is has not yet been evaluated against the criteria.

Introduction

The global amphibian assessment by Stuart *et al*. (2004) brought attention to the precarious situation of many amphibian species. Globally, amphibians are undergoing an unprecedented decline with 41% of all species known to be threatened (Monastersky, 2014). The current rate of amphibian species loss is more than 200 times the average background extinction rate (Roelants *et al*., 2007).

Madagascar ranks amongst the richest countries in the world for its amphibian diversity and harbours over 300 described species and an estimated 200 or more undescribed candidate species of frog (Myers *et al*., 2000, Mittermeier *et al*., 2011; Andreone *et al*., 2012; Perl *et al*., 2014). These account for approximately 4% of the world's amphibian species, despite the island covering less than 0.4% of the Earth's land surface area (Yoder & Nowak, 2006; Andreone *et al*., 2012). The island has extremely high levels of endemism, with all but one autochthonous amphibian species and 88% of genera found nowhere else on Earth (Glaw & Vences, 2007). Madagascar's endemic amphibian species belong to three families: the Hyperoliidae, Mantellidae and Microhylidae (Glaw & Vences, 2007). Much of this diversity belongs to two large radiations: one within the mantellids, and another in the cophyline microhylids (Van der Meijden *et al*., 2007). Madagascar's non-endemic amphibian species occur within the Bufonidae, Dicroglossidae and Ptychadenidae (Glaw & Vences, 2007; Andreone *et al.,* 2014; Kolby *et al*., 2014). The Ptychadenidae are represented by just a single species, *Ptychadena mascareniensis*, which also occurs throughout mainland Africa (Vences *et al*., 2004). However, Malagasy populations of *P. mascareniensis* show high levels of genetic variation compared to those from the African mainland, while populations from the far north of Madagascar are highly differentiated from those to the south, indicating this species likely naturally dispersed to the island naturally (Vences *et al*., 2004). Of the Dicroglossidae, only *Hoplobatrachus tigerinus* is present; it was likely introduced from southern Asia by humans and is now widespread in northern Madagascar (Kosuch *et al*., 2001). The Bufonidae are represented by a recent incursion of *Duttaphrynus melanostictus,* found near the eastern city of Toamasina (Andreone *et al*., 2014).

A recent review of the island's amphibians found 66 species were threatened out of a considered 242; six are categorised as Critically Endangered, 31 as Endangered and 29 as Vulnerable (Andreone *et al*., 2012). In response to this a number of national conservation strategies have outlined methods to address these declines (Andreone *et al*., 2005; Andreone & Randriamahazo, 2008; Rosa *et al*., 2015). This action plan focuses on the Sahamalaza Peninsula in Northwest Madagascar, an understudied area that is known to harbour a number of CR local endemics (Vences *et al*., 2005, 2010; Penny *et al*., 2014).

Factors contributing to amphibian population decline on a national scale

- **Habitat destruction**

Madagascar has lost more than 90% of its original forest cover, experiencing a 33% reduction in primary forest since the 1970s (Moat & Smith, 2007). Around 150,000 hectares of forest

are felled each year and if this trend continues then all primary vegetation will be lost by 2067 (Moat & Smith, 2007). Many amphibian species are sensitive to environmental change and the greatest contributory factors to amphibian extinctions are habitat destruction and fragmentation; unless this situation improves further declines can be expected (Vallan, 2002; Young *et al*., 2004; Andreone *et al*., 2005).

Anthropogenic disturbance causes a reduction in species diversity and the size of forest fragments appears to be negatively correlated with amphibian biodiversity (Vallan, 2000). Degraded habitats usually show reduced structural complexity and support fewer microhabitats than intact habitat, with features such as streams and ponds often destroyed or fundamentally altered (Inger & Colwell, 1977; Vallan, 2002). Plant species diversity often declines following human disturbance, followed by a cascade of further losses at higher trophic levels (Cody, 1975). Typically, disturbance will change an area's species composition; specialists are replaced by generalists, and endemics are replaced by non-endemics (Vallan, 2004; Irwin *et al*., 2010).

Malagasy western dry forests are one of the most threatened habitat types in Madagascar; there has been a decline in primary forest cover from 12.5% in 1950 to 2.8% in 1990 (Smith *et al*., 1997; Pons *et al*. 2003; Elmqvist *et al*., 2007). This is because of its susceptibility to fire and conversion to agricultural land (Janzen, 1988). Prevention methods were confounded by the recent political crisis, where the strength of government enforcement weakened following a political coup in 2009 (Andreone *et al*., 2012; Schwitzer *et al*., 2014).

- **Climate change**

It is likely that the effects of global warming and its impact on weather frequency and pattern will lead to future amphibian decline (Stuart *et al*., 2004; Pachauri and Reisinger, 2007; Kujala *et al*., 2013). The effects of climatic change are already visible within many ecosystems and phenological shifts, changes in species range and alterations in community composition have been well documented (Parmesan, 2006). Water quality and water availability are directly affected by changes in rainfall pattern; this in turn can impact amphibian reproductive success (Walls *et al*., 2013). In Madagascar, global warming will exacerbate the effects of isolation, fragmentation and limited size of amphibian natural habitats by preventing or limiting species migration and adaptation (Hannah *et al*., 2002; Moat & Smith, 2007; Raxworthy *et al*., 2008; Kharouba and Kerr, 2010).

- **Overharvesting**

Several Malagasy frog species suffer from the effects of overharvesting. Each year thousands of colourful frogs are exported in the pet trade, particularly *Mantella* species, *Dyscophus* species and *Scaphiophryne* species (Andreone *et al*., 2006; Rabemananjara *et al*., 2008). Other frogs are wild-caught for consumption, such as *Mantidactylus grandidieri*, *M. guttulatus* and *Boophis goudoti* (Jenkins *et al*., 2009).

- **Disease**

The disease chytridiomycosis, caused by the fungus *Batrachochytrium dendrobatidis* (*Bd*), is considered to be one of the greatest contributory factors to global amphibian decline and has been identified in 48% of the world's frog species (Fisher *et al*., 2009; Olson *et al*., 2013). Infection rates are likely higher than this, as many species have not been sampled, and *Bd* continues to spread into previously disease-free regions (Olson *et al*., 2013). The fungus was first recorded in Madagascar in 2010 but it remains unclear whether the pathogen was recently introduced or endemic to the island (Kolby*,* 2014; Bletz *et al.,* 2015a, 2015b). It appears to be quite widespread and shows signs of seasonality, having a higher chance of detection in the dry, cold season (Bletz *et al*., 2015a). As well as Bd, ranavirus has now also been detected in wild amphibian populations in Madagascar (Kolby, 2014; Kolby *et al.,* 2015). Together, these highlight the importance of continued and standardised disease monitoring within the country, as both chytridiomycosis and ranaviral diseases have the potential to contribute toward future amphibian declines in Madagascar (Lötters *et al*., 2011; Andreone *et al*., 2012; Weldon *et al*., 2013; Bletz *et al*., 2015a, 2015b; Kolby *et al.,* 2015).

- **Invasive species**

Sightings of the Asian common toad (*Duttaphrynus melanostictus*) were recently reported from Toamasina and its vicinity (Moore *et al*., 2015), if this population is not eradicated immediately it has the potential to spread throughout Madagascar (Crottini et al., 2014). Besides being in competition with native amphibian species, this population of introduced toads might also act as a reservoir and vector for amphibian pathogens (Kolby *et al*., 2014; Andreone *et al*., 2014; Bletz et al., 2015a; Kolby *et al.,* 2015). Many Malagasy frogs have only small range distributions, so a disease outbreak could be highly damaging (Lötters *et al*., 20011; Andreone *et al*., 2012).

Conservation action plan for the Sahamalaza Peninsula

Focal site

The Sahamalaza Peninsula is in the province of Mahajanga, Northwest Madagascar (Fig. 1). The peninsula covers approximately 26,000 hectares and is defined by the Sahamalaza Bay to the east, the Mozambique Channel to the west and the Loza River to the south (located between 13° 52' S - 14° 27' S, and 45° 38' E - 47° 46' E; Volampeno, 2009). Parts of the peninsula were designated a UNESCO Biosphere Reserve in 2001; this was followed by the creation of the Sahamalaza-Iles Radama National Park in July 2007 (Schwitzer *et al*., 2007).

The sub-humid climate has two distinct seasons: a cooler, drier season (May to November) and a hotter, wetter season (December to April). Monthly mean maximum temperature ranges from 28.5 ± 3.61 ºC in July to 39.1 ± 2.11 ºC in February; and monthly mean minimum temperature ranges from 13.2 ± 0.81 ºC in October to 21.8 ± 0.81 ºC in January (Volampeno *et al*., 2011). Rainfall is highest during January and February and the mean annual precipitation rate is around 1600 mm (Schwitzer *et al*., 2007). This climate supports a unique type of hybrid forest, comprised of over 200 plant species within 68 families,

harbouring species from both the wetter Sambirano domain and drier western domain (Ralimanana & Ranaivojaona 1999; Birkinshaw, 2004; Schwitzer *et al*., 2006).

The forests of Sahamalaza are concentrated into two separate regions: Anabohazo (14° 18.56' S, 47° 54.89' E) and Ankarafa (14° 22.82' S, 47° 45.46 'E); separated from one another by around 20 km of savannah and scrubland (Fig. 1). Forest in Ankarafa is further fragmented into a matrix of smaller fragments (Schwitzer *et al*., 2007), while in Anabohazo the largest forest fragments are Berara and Ankatsaikely. Until recently a third forested region existed, Analavory (14° 23.30' S, 47° 56.15' E), but this experienced near complete destruction following an uncontrolled man-made fire in 2004 (Volampeno, 2009).

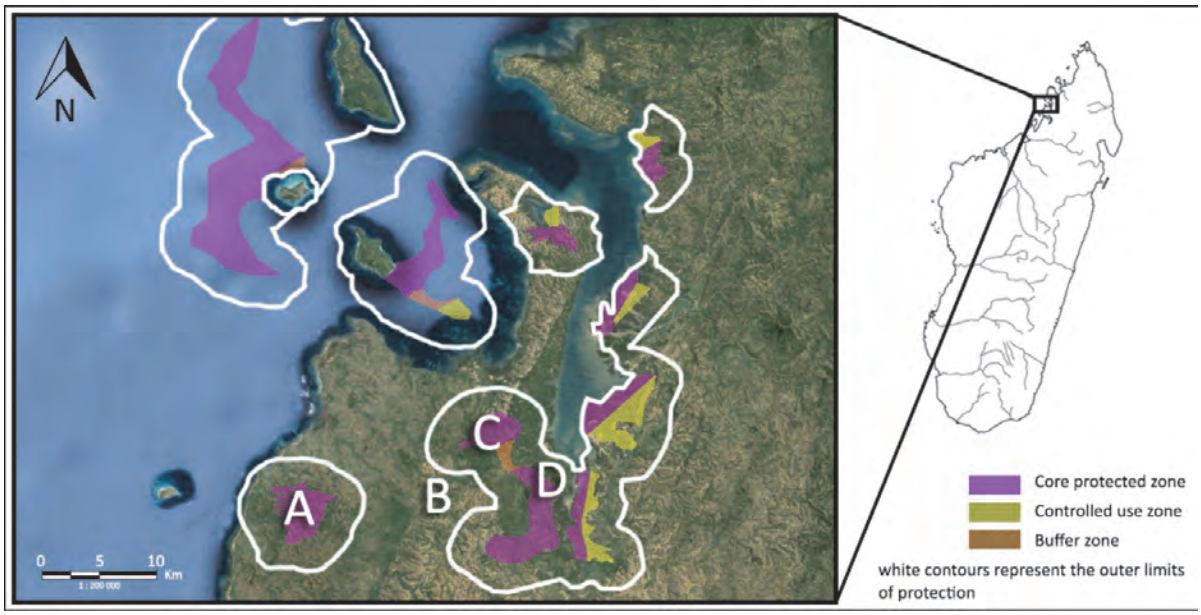

Figure 1. The Sahamalaza Peninsula in northwest Madagascar, indicating the locations of (A) Ankarafa Forest (B) Antafiabe Village (C) Anabohazo Forest and (D) Betsimpoaka village. Source: Penny *et al*., 2014.

Factors contributing to amphibian population decline on a local scale

Despite receiving formal protection, forest on the Sahamalaza Peninsula is subject to unsustainable levels of exploitation by the local human population (Seiler *et al*., 2012; Penny *et al*., 2014). The greatest threat to the area's amphibians is habitat loss: primarily slash-and-burn agriculture, known locally as *tavy*. This is rife both inside and outside the boundaries of the park which coupled with the lack of any law enforcement leaves the few remaining patches of forest and its fauna in a perilous state (Seiler *et al*., 2012; Penny *et al*., 2014).

In Ankarafa, no large areas of primary forest remain and all fragments are exposed to some degree of anthropogenic disturbance and edge effects (Schwitzer *et al*., 2007). Eight active areas of *tavy* clearance (Fig. 2a) were encountered between October 2011 and January 2012 (ranging between 1-6 hectares), representing an increase in destruction on previous years. There are only around 185 hectares of forest remaining in Ankarafa, thus if the current rates of destruction continue there may be no forest remaining in 10-20 years.

Anabohazo also suffers from high levels of forest clearance (Fig. 2b). The fragment of Berara harbours the largest area of primary forest remaining on the peninsula; likely protected from agricultural conversion by its steep terrain and seasonal water supply. However, clearance is occurring on its lower slopes and threatens to penetrate into the interior; the selective logging of tropical hardwoods is also ongoing. The neighbouring fragment of Ankatsaikely is more degraded and largely consists of secondary regrowth. It has been subject to extensive *tavy* clearance within recent years and a number of families have settled within the boundaries of the park. Much of Ankatsaikely's remaining forest is immature secondary regrowth.

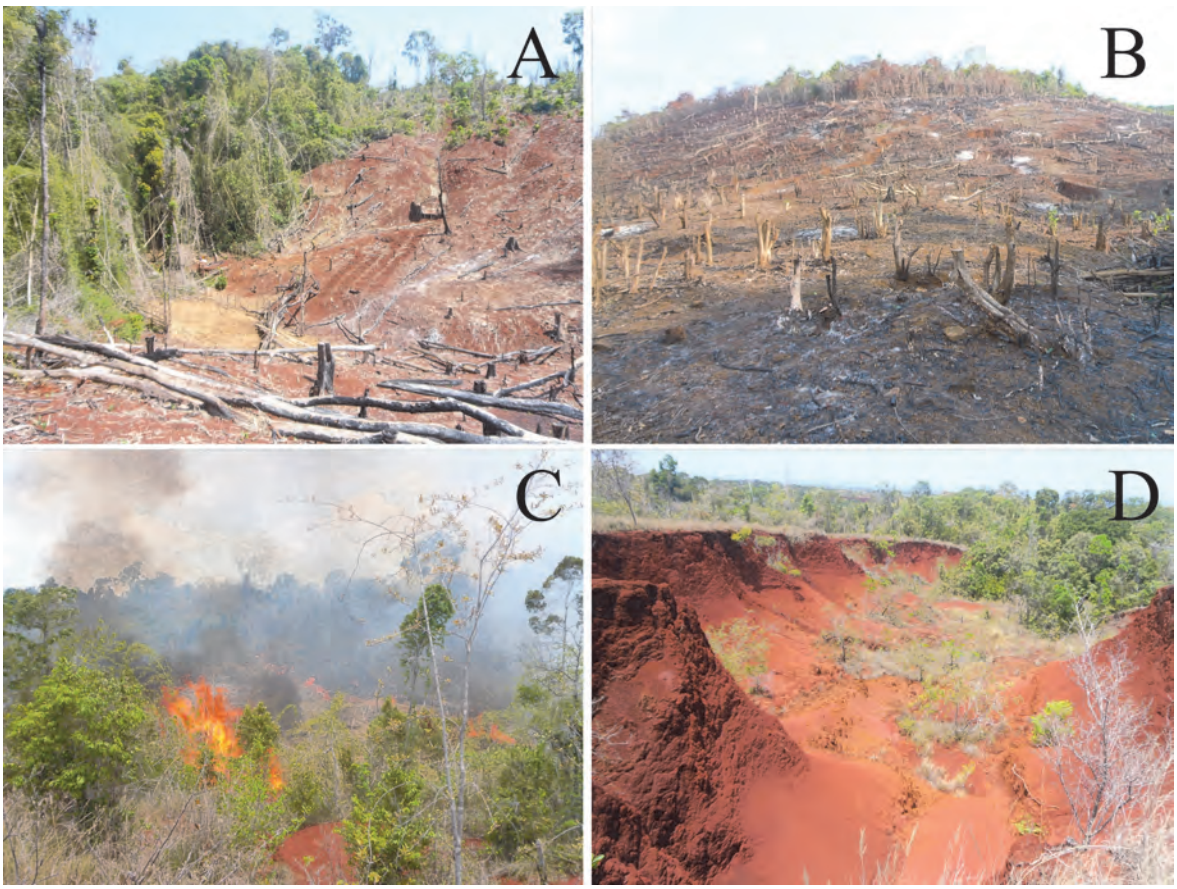

Figure 2: Degradation across the Sahamalaza Peninsula **(A)** *Tavy* clearance in Ankarafa Forest (November 2011; 14° 23.09' S, 47° 44.92' E); **(B)** *Tavy* clearance in Anabohazo Forest (December 2011; 14° 19.50' S, 47° 54.69' E); **(C)** Forest fire in Ankarafa (November 2011; 14° 23.20' S, 47° 44.80' E); **(D)** Soil erosion in Ankarafa (November 2011; 14° 22.94' S, 47° 44.79' E) (Photos: Samuel G. Penny).

Any forest remaining outside the core zones of the park is patchy and degraded, largely confined to hilltops and steep slopes. The landscape predominantly consists of savannah interspersed with copses of mango; large craters caused by soil erosion are also prominent features (Fig. 2d). Zebu cattle roam freely throughout the park and their grazing, along with the regular burning of grassland to rejuvenate pastureland, prevents the natural regeneration of forest. These fires are lit in the late dry season, and with no means to control their spread often rage through adjacent areas of forest (Fig. 2c). All areas of intact forest are highly vulnerable to destruction and at risk of being destroyed completely, as has already occurred with Analavory Forest (Volampeno, 2009).

Villagers are increasingly aware that laws protecting the forest are rarely enforced. The increased rates of forest destruction occurring throughout Sahamalaza appear to be driven by the return of local villagers previously evicted from the land after the creation of the national park in 2007. This is further confounded by the lack of a visible boundary demarcating which areas fall inside the zone of protection, with much disagreement and confusion in local population over where this boundary lies. A number of local people were also found to view researchers and field staff working within the park in a negative light, perceiving them as occupiers of land that was historically their own.

Degradation shows no signs of abating and the remaining forest looks set to decline further in habitat quality and size. The greatest levels of clearance are occurring within streamside vegetation and riparian forest. Many Malagasy amphibian species breed in riverine environments and their reproductive success is dependent on the preservation of these habitats (Glaw & Vences, 2006; Penny *et al*., 2014). Streams are further affected by irrigation channels dug to water crops and run-off from soil erosion; changes in water availability and water quality, which may become exacerbated by future climate-induced changes in hydrology, will further impact on these amphibian populations (Walls *et al*., 2013). The destruction of these habitats, which are essential for the survival of the locally endemic frog species, may ultimately lead to their extinction; while the other forest-dependent frog species may become extirpated.

Amphibian fauna of the Sahamalaza Peninsula

A total of 20 amphibian species are known from the Sahamalaza Peninsula (Table 1). The composition of the peninsula's amphibian fauna reflects its transitional climate between the wetter Sambirano domain and drier western domain. Species representative of the drier biomes of western Madagascar (*Aglyptodactylus securifer*, *Heterixalus luteostriatus*, *H. tricolor* and *Blommersia* sp. Ca5) occur concurrently with species representative of the wetter rainforests to the north (*Boophis brachychir, B. jaegeri, B. tephraeomystax*; *Gephyromantis pseudosasper, Stumpffia gimmeli* and *Mantella ebenaui*). The area also supports a high level of microendemism, with at least three species restricted to Sahamalaza (*Boophis ankarafensis, Boophis tsilomaro* and *Cophyla berara*). The status and distributions of a further three candidate species are unclear but they may also represent local endemics (*Platypelis* sp. aff. *cowanii, Rhombophryne* sp. aff. *alluaudi* and *Stumpffia* sp. aff. *pygmaea*). Other species present have a more widespread distribution and occur across much of Madagascar (*Laliostoma labrosum, Ptychadena mascareniensis* and *Mantidactylus ulcerosus)* or in the case of *Hoplobatrachus tigerinus* are non-endemics.

Two species are classified as threatened following the IUCN Red List Categories; the frog *Cophyla berara* is Critically Endangered, while *Boophis jaegeri* qualifies as Vulnerable. *Boophis ankarafensis* and *B. tsilomaro* also meet the criteria of Critically Endangered but have not yet been officially evaluated. The three candidate species along with *Blommersia* sp. 5 MV-2009 have not been formally described and thus have yet to be evaluated. *Boophis brachychir* is Data Deficient but most likely will be evaluated as Least Concern, whilst the remaining eleven species qualify as Least Concern.

The two forests of Anabohazo and Ankarafa harbour slightly different species compositions but are broadly similar (Table 1). Four species are known exclusively from Anabohazo, while three were found in Ankarafa but not Anabohazo. Of the three local endemics *Boophis ankarafensis* and *B. tsilomaro* are known exclusively from Ankarafa Forest and Anabohazo Forest respectively, while *C. berara* is known from both forests. Of the four candidate species, *Rhombophryne* sp. aff. *alluaudi* and *Platypelis* sp. aff. *cowanii* are known solely from Anabohaozo Forest while *Stumpffia* sp. aff. *pygmaea* and *Blommersia* sp. Ca5 are known from both Anabohazo and Ankarafa. This highlights the importance of protecting all of the remaining areas of natural habitat on the peninsula, as populations may be dependent on narrowly defined niches.

Table 1: Distribution and IUCN Red List status of amphibian known from the Sahamalaza Peninsula. The survey at Analavory Forest (14°23.30' S, 47°56.15' E) was conducted by Raselimanana (2008), while previous surveys at Anabohazo Forest (14°18.6' S, 47°54.9' E) and Betsimipoaka Village (14° 19.79' S, 47°57.76' E) were conducted by Andreone *et al*. (2001). The most recent survey conducted in 2011-13 revisited Anabohazo Forest and Betsimipoaka Village, and also surveyed Ankarafa Forest (14°22.8' S, 47°45.5' E) and Antafiabe Village and its surroundings (14°21.3' S, 47°52.1' E).

	1996	**2000**	**2013**	**2000**	**2011-13**	**2011-13**	**2011**	**IUCN Red List Status**
	Analavory	Betsimipoaka		Anabohazo		Ankarafa	Antafiabe	
Dicroglossidae								
Hoplobatrachus tigerinus						+	+	LC
Hyperoliidae								
Heterixalus luteostriatus		+	+		+	+		LC
Heterixalus tricolor						+		LC
Mantellidae								
Aglyptodactylus securifer			+	+	+	+		LC
Blommersia sp. Ca5					+	+		NE
Boophis ankarafensis						+		NE
Boophis brachychir					+	+	+	DD
Boophis jaegeri				+	+	+		VU
Boophis tephraeomystax	+		+		+	+	+	LC
Boophis tsilomaro				+	+			NE
Gephyromantis pseudoasper				+	+			LC
Mantella ebenaui		+		+	+	+		LC
Mantidactylus ulcerosus				+	+	+	+	LC
Laliostoma labrosum	+							LC
Microhylidae								
Cophyla berara				+	+	+	+	CR
Platypelis sp. aff. *cowanii*				+				NE
Rhombophryne sp. aff. *alluaudi*				+				NE
Stumpffia gimmeli					+	+		LC
Stumpffia sp. aff. *pygmaea* "Sahamalaza"					+	+		NE
Ptychadenidae								
Ptychadena mascareniensis	+		+		+	+	+	LC

Proposed actions

The greatest threat to Sahamalaza's amphibian diversity is from the destruction of its natural habitats. To prevent further decline in the area's already endangered species, all destruction within the park must stop immediately. This must include the selective logging of tropical hardwoods, the clearing of land for crop cultivation and the burning of savannah to rejuvenate pasture land. A number of actions must be taken to tackle this, including assisting local people in the development of alternative livelihoods and improved community engagement and education on the importance of conservation (Table 2).

Table 2: Objectives and recommended actions to assist in the conservation of the amphibian fauna of the Sahamalaza Peninsula. Timeframe: Short (1-2 years), Medium (3-5 years), Long (>5 years or ongoing).

Objectives	Actions	Actors	Timeframe
Evaluate the conservation status of all species present.	Produce a comprehensive itinerary of Sahamalaza's amphibian fauna.	Survey team	Complete
	Ensure all new species are scientifically described.	Survey team	Short
	Assess the IUCN Red List status of all species encountered.	Survey team	Short
	Update online databases and profiles for all species encountered.	Survey team	Short
Increase awareness about amphibian conservation.	Train local Malagasy guides and students in amphibian field methods.	Survey team	Medium
	Produce an acoustic guide to the amphibians of Sahamalaza and make it accessible for education and future research.	Survey team	Short
	Provide local schools with resources to engage pupils in amphibian conservation, such as posters leaflets and books.	BZS	Medium
	Sponsor and organise community-wide social events.	AEECL BZS	Long
Halt all forest clearance and agricultural practises within the park.	Demarcate existing protected areas	AEECL	Short
	Employ local rangers to patrol protected areas.	AEECL	Long
	Organise regular research visits to all areas of the park, ideally at least one per year to the two remaining forested areas	AEECL BZS MNP	Long
	Establish a second research station in Anabohazo Forest.	AEECL	Medium
Provide local people with a sustainable means of employment and sustenance.	Encourage alternative farming practises to slash-and-burn agriculture such as the raising of chickens and keeping of bees.	AEECL BZS	Long
	Establish tree plantations outside protected areas that can be utilised by local people.	AEECL MNP	Long
	Provide fuel-efficient stoves to reduce reliance on gathering firewood from inside the park.	BZS MBP	Short
	Establish a community-based ecotourism project.	AEECL	Medium
Reverse amphibian population decline in Sahamalaza.	Increase suitable amphibian habitat and connectivity through reforestation schemes.	AEECL	Long
	Gather information on breeding habits and evaluate the success of establishing an *ex situ* captive breeding colony.	BZS	Short

Evaluate the conservation status of all species present

- **Produce a comprehensive itinerary of Sahamalaza's amphibian fauna**
- **Ensure all new species are scientifically described**
- **Assess the IUCN Red List status of all species encountered**
- **Update online databases and profiles for all species encountered.**

We are confident that a significant proportion of the amphibian species from the Sahamalaza Peninsular have now been detected. This is supported by a plateauing in the rate of species detection following the most recent survey effort (to be published). All species of taxonomic uncertainty will be scientifically described, as has recently occurred for *Boophis ankarafensis* (Penny *et. al*., 2014). This will allow the conservation status of all Sahamalaza's species to be formerly classified on the IUCN Red List, while the status of all prior listed species will be updated. To increase the reach and impact of this research online databases and species profiles will be updated to reflect our findings.

Increase awareness about amphibian conservation

- **Train local Malagasy guides and students in amphibian field methods.**

The employment of local Malagasy project staff at the research stations will give them a basic knowledge of amphibian identification, ecology and preservation. Through this they will become aware of amphibian conservation issues and be encouraged to transfer their knowledge to their local communities, essential for local support of conservation. Their specialist knowledge will provide them with valuable skills to aid future researchers, as well as increasing their employability for future conservation projects, such as the community-based ecotourism project currently being set up by the AEECL near Ankarafa Forest.

- **Produce an acoustic guide to the amphibians of Sahamalaza and make it accessible for education and future research.**
- **Provide local schools with resources to engage pupils in amphibian conservation, such as posters leaflets and books.**

The descriptions of the acoustic repertoires of Sahamalaza's frog species and an acoustic library of their vocalisations will be made freely available. These will be an important taxonomic tool in future field surveys, providing a quick and easy method to distinguish between different species. A similar product has been published on the amphibians of RNI de Betampona (Rosa *et al.,* 2011). Furthermore, the creation of an acoustic library transcends the language difficulties often present within foreign-led research programmes, making a simple identification tool accessible to local people. This can be distributed online as well as on external memory cards provided to local schools that can be inserted into mobile phones. Schools should also be provided with resources that allow them to engage children about the importance of local conservation such as pictorial guides to amphibian identification, as well as posters and books on the benefits of forest conservation.

- **Sponsor and organise community-wide social events.**

Community-wide social events are vital for raising conservation awareness, building goodwill with the local population and in creating positive relationships between researchers, field staff and villagers. Past successful activities include the construction of firebreaks followed by feasting in Ankarafa Forest and the organisation of festivities by conservation organisations. An existing annual festival celebrating lemurs and their conservation, funded by the AEECL, should be expanded to cover all Sahamalaza's endangered fauna with more resources allocated to this event. A similar initiative was held in Maroantsetra (NE Madagascar) by the Madagascar Fauna and Flora Group together with Amphibian Specialist Group (Andreone *et al.,* 2013). By engaging local people in the protection of the forest and educating them about the long-term benefits it can bring them, it is hoped they will view it as an asset of the community, rather than a loss of land inflicted on them by the national government or foreign NGOs. Programmes that encourage conservation through education and community engagement are likely to be the most effective long-term strategy in protecting the park's amphibian species as many policies are worthless without local support. Establishing a field station in Anabohazo would allow an extension of these activities to another part of the peninsula.

Halt all forest clearance and agricultural practice within the park

- **Demarcate existing protected areas**
- **Employ rangers to patrol protected areas.**

The park's boundaries must be clearly demarcated by signage to ensure that resources within the park are not unwittingly exploited; this current ambiguity can be seen in confusion within the neighbouring communities as to which areas of land are protected. The current vacuum in all forms of law enforcement allows local people to exploit the park's resources. Therefore a team of park rangers should be employed to patrol the area and deter would-be loggers and settlers within the park. The threat of reporting this to a law enforcement agency should lead to an immediate reduction in destruction of the park. Local people should be employed for this role, which will provide an alternative source of income to the destructive practice of *tavy* clearance and be vital gaining the communities' respect.

- **Organise regular research visits to all areas of the park, ideally at least one per year to the two remaining forested areas**
- **Establish a second research station in Anabohazo Forest.**

The presence of researchers and associated field staff should be increased throughout all areas of intact habitat; it seems that the continuous presence of field staff acts as a deterrent to the exploitation of the forest (Seiler *et al*., 2010). The establishment of an AEECL (Association Européenne pour l'Etude et la Conservation des Lémuriens) run research station in the core of Ankarafa Forest in 2004 has helped to protect the surrounding areas of forest; the fragments closest to the research station have seen the least amount of degradation. The construction of a second field station in Anabohaozo should produce similar benefits, with a constant staff presence reducing levels of illegal logging and land clearance. Until this can be

set up, more regular visits to Anabohazo should be made, as the current survey was the first research trip to the area since 2004.

Provide local people with a sustainable means of employment and sustenance

- **Encourage alternative farming practises to slash-and-burn agriculture such as the raising of chickens and keeping of bees.**
- **Establish tree plantations outside protected areas that can be utilised by local people.**
- **Provide fuel-efficient stoves to reduce reliance on gathering firewood from inside the park.**

As well as hosting community events, workshops should be established that educate and provide local people with the means to establish permaculture farming practises. This could include agroforestry along with more standard practises such as crop rotations; this will reduce the effects of soil degradation and reduce reliance on slash-and-burn agriculture. The destruction of forest through slash-and-burn agriculture only benefits a small number of people, with 16 dwellings inside the boundaries of the national park in 2012. These people rely on shifting cultivation for their sustenance and thus it must be a priority to provide alternative employment opportunities to discourage them from returning to the forest after eviction. Left intact, the forest will benefit a much wider group of people and it is these benefits the local population must be made aware of, such as the positive impact on soil quality and the local hydrological cycle and the alternative employment opportunities conservation of the forest can supply. Much of this would require high cost inputs from external NGOs; more cheaply, existing farming practises can be made more efficient through simple husbandry improvements. For example chicken raising can be improved through the provision of predator-proof night housing and independent chick rearing and egg-laying quarters.

Forest regeneration schemes can benefit local people as well as wildlife. Many areas of the peninsula are comprised of scrubland and eroded zones that are unused by farmers and herders. Tree plantations established here solely for the use of the local population would reallocate the collection of firewood and timber away from protected areas of forest. The introduction of fuel-efficient rocket stoves (*Fatapera mitsitsy*) as trialled around Kianjavato Forest in the Vatovavy Fitovinany region would further decrease demands on the forest (Schwitzer *et al*., 2013).

- **Establish an ecotourism project and employ local people.**

A community-based ecotourism project is currently being set up by the AEECL near Ankarafa Forest. Employment here along with jobs at the research stations and as rangers will provide local people with a source of income dependent on the protection of Sahamalaza's Forests.

Reverse amphibian population decline in Sahamalaza

- **Increase suitable amphibian habitat and connectivity through reforestation schemes.**

Once these immediate actions have been put into place focus should be moved towards reforestation projects to link the matrix of smaller fragments, a necessary step in the long-term stability and sustainability of amphibian populations. The costs of tree planting can be high; an alternative is to create fenced exclosure plots that prevent cattle grazing and allow a natural transformation from savannah to scrub and ultimately forest. This will result in a different floral composition and structure to that of intact forest, however, any forest cover is preferable to open grassland and should allow movement between isolated populations of more environmentally-sensitive and arboreal amphibian species. If possible this should be used in tandem with tree planting, and a nascent reforestation scheme has already been begun by the AEECL (Randriatahina, 2013). It is important that this project is sustained and expanded. Resources would be best concentrated on reforesting the roughly four hectares of savannah that divide Berara and Ankatsekely fragments in Anabohazo (focal point 14° 19.01' S, 47° 55.05' E), where the only known populations of *Boophis tsilomaro* are found. In addition, two areas of savannah (ca. 6 ha) that split Ankarafa into five small fragments adjacent to the only known population of *B. ankarafensis* (focal points 14° 22.65' S, 47° 45.58' E and 14° 22.95' S, 47° 45.65' E) should also be replanted.

- **Gather information on breeding habits and evaluate the success of establishing an *ex situ* conservation programme.**

Finally, the feasibility of establishing a captive breeding colony should be investigated for the conservation of the CR local endemics, with a preference towards an in-country location. If current levels of forest loss do not slow, then Sahamalaza's endemic species may be lost within the next few years. A separate breeding colony would insure against possible future extinction events. The chance of future chytrid disease outbreaks, which could decimate the area's amphibian populations, further increases the case for captive breeding. Knowledge can be gained from the recently set up community-run amphibian captive breeding programme in Mitsinjo near Andasibe, the first (although not unique) of its kind in the country (Edmonds, 2011). If deemed successful the husbandry techniques learnt in breeding closely related species along with knowledge of the associated logistic and bureaucratic challenges can be adapted for use in a separate project, preferably in or near Sahamalaza. This would have the added benefit of employing local people and providing opportunities to engage with local communities about the importance of local conservation work. This is conditional on further research being carried out on the biology and ecology of the understudied prospective captive species before they are entered into a breeding programme. However, captive breeding should not be seen as an alternative to *in situ* techniques, but instead as a supplementary activity, as the most effective conservation polices occur *in situ*. Most importantly any future policy decisions on breeding programmes should only be made if there is a high confidence of success as any disruption could be disastrous in the already threatened populations of frogs.

Species-specific occurrence and threats

Dicroglossidae

Hoplobatrachus tigerinus (Daudin, 1803) Indian Bullfrog

IUCN Red List Status: Least Concern in its native distribution area; introduced in Madagascar (Padyhe *et al*., 2008; Kosush *et al*., 2001).

Hoplobatrachus tigerinus (Fig. 3a) belongs to the subfamily Dicroglossinae and is the largest frog species in Madagascar. This species is non-native to Madagascar and was likely introduced from the Indian subcontinent by humans (Kosuch *et al*., 2001). Present on the Sahamalaza Peninsula, it is known from Ankarafa Forest and the village of Antafiabe (Table 1), it is has also been widely documented from the northeast and northwest areas of the country (Glaw & Vences, 2007).

Common throughout large parts of India, Bangladesh and much of northern Pakistan, *H. tigerinus* is ranked as Least Concern on the IUCN Red List, and so the conservation and protection of this species is not a priority (Padyhe *et al*., 2004). This species was present in human-modified habitats in Sahamalaza such as paddy fields, and so populations are unlikely to suffer a significant decline as natural habitats become converted to agricultural land. Its impact on Sahamalaza's native species is unknown and still requires evaluation, but may include competition for prey, consumption of young heterospecific frogs or interference with native species' advertisement calls (Khan, 1973; Tennessen *et al*., 2013).

Hyperoliidae

Heterixalus luteostriatus (Andersson, 1910) Andranolava Reed Frog

IUCN Red List Status: Least Concern (Nussbaum *et al*., 2008)

The treefrog *Heterixalus luteostriatus* (Fig. 3b) is a member of the family Hyperoliidae. Found across Sahamalaza (Table 1), the species appears well adapted to habitats subjected to moderate levels of degradation, and is likely to occur outside of the protected forests amongst rice fields and other stagnant water bodies (Nussbaum *et al*., 2008). It is classified as Least Concern by the IUCN Red List and so does not constitute a priority for conservation (Nussbaum *et al*., 2008).

Heterixalus tricolor (Boettger, 1881) Three-color Reed Frog

IUCN Red List Status: Least Concern (Nussbaum *et al*., 2008).

Heterixalus tricolor (Fig. 3c) is a member of the family Hyperoliidae. In Sahamalaza the species is only known from Ankarafa Forest (Table 1); outside of Sahamalaza it occurs on the islands of Nosy Be and Nosy Komba to the North and Ankarafansika and Kirindy to the South (Glaw & Vences, 2007). Consequently, this new record completes a gap in this species range distribution and confirms this species' wide distribution along the western side of

Madagascar. Although found in low numbers in Sahamalaza, the species is not dependent on intact forest and so is unlikely to be at risk of significant decline in the future (Nussbaum *et al*., 2008).

Mantellidae

***Aglyptodactylus securifer* Glaw, Vences and Böhme, 1998 Kirindy Jumping Frog**

IUCN Red List Status: Least Concern (Glaw & Vences, 2008)

Aglyptodactylus securifer (Fig 3d) is a member of the subfamily Laliostominae. In Sahamalaza the species is known to occur in forested areas (Table 1) and has a relatively wide distribution across western Madagascar (Glaw & Vences, 2007). Although listed as Least Concern, populations are thought to be declining due to their reliance on forest habitat (Glaw & Vences, 2008). Thus populations in Sahamalaza are likely to be decreasing.

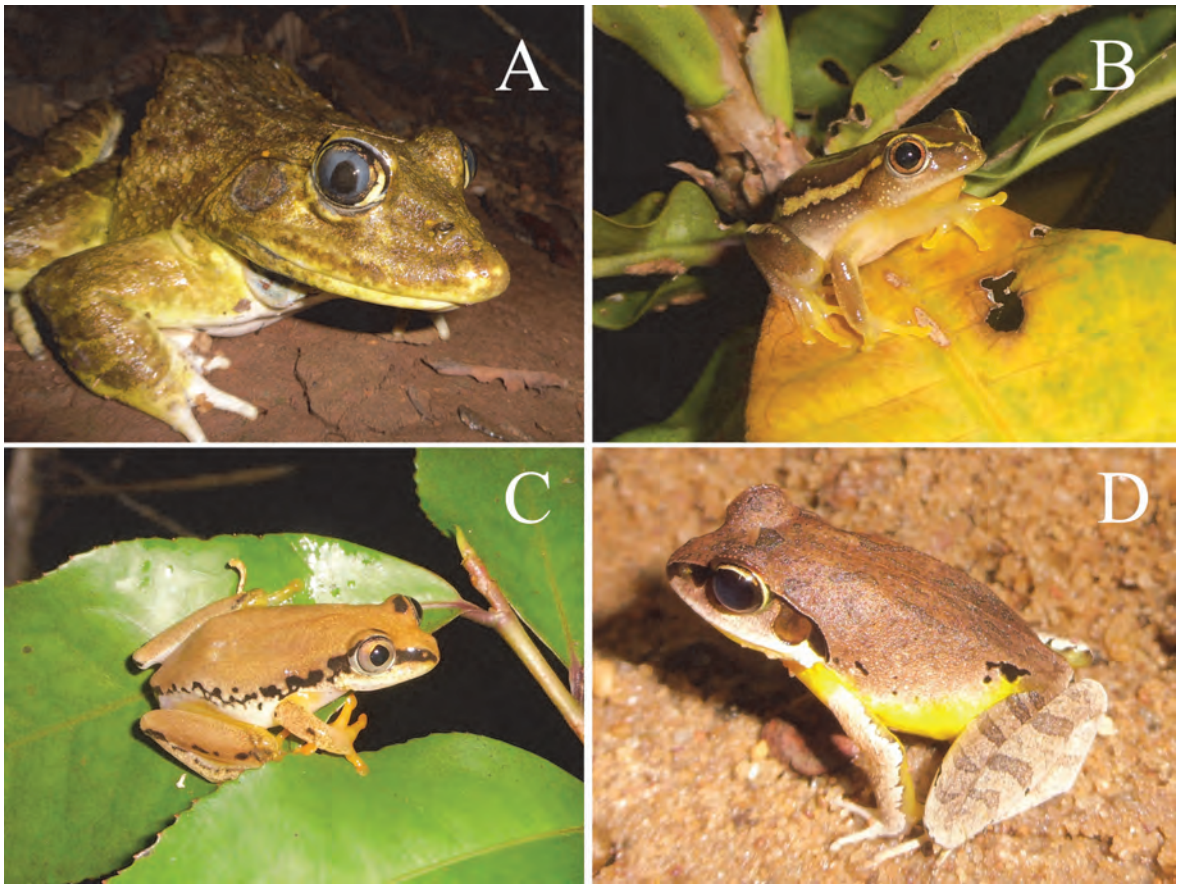

Figure 3: (A) *Hoplobatrachus tigerinus* **(B)** *Heterixalus luteostriatus* **(C)** *Heterixalus tricolor* **(D)** *Aglyptodactylus securifer* (Photos: Samuel G. Penny).

***Blommersia* sp. Ca5**

IUCN Red List Status: Not Evaluated

This species is currently awaiting description. Genetic analysis of mitochondrial DNA of individuals from Sahamalaza identified a 99% shared identity with *Blommersia* sp. Ca5 from

Isalo, Makay and Kirindy. *Blommersia* sp. Ca5 (Fig. 4a) was detected from forested areas on the peninsula (Table 1); this extends their known range further north than the other documented populations. It thus appears to be quite widely distributed throughout the west of Madagascar.

This species was relatively abundant across the peninsula with individuals detected from along streams and ponds within intact forest but also from the surrounds of paddy fields and cleared areas, indicating adaptability to disturbance. This species' adaptability to degraded habitats and relatively wide geographic distribution means that this species is not at immediate risk. However, in order to identify any potential threats an accurate bioacoustic and morphologic analysis is required to fully clarify its taxonomic status and help characterise its full range.

Figure 4: (A) *Blommersia* sp. Ca5 **(B)** *Boophis ankarafensis* **(C)** *Boophis brachychir* **(D)** *Boophis jaegeri* (Photos: Samuel G. Penny).

Boophis ankarafensis **Penny, Andreone, Crottini, Holderied, Rakotozafy, Schwitzer & Rosa, 2014 Ankarafa Skeleton Frog**

IUCN Red List Status: Not Evaluated

Boophis ankarafensis (Fig. 4b) is a member of the subfamily Boophinae, within the *B. rappiodes* group. This species was recently described from Ankarafa Forest and it appears to be restricted to the Sahamalaza Peninsula (Penny *et al*., 2014). Breeding individuals were

only located along perennial streams in intact forest, which appears to be a condition for this species' presence. This habitat type is extremely rare on the Sahamalaza Peninsula and entirely absent from Anabohazo, the only other significant area of forest remaining on the peninsula. If other populations exist on the peninsula they would likely be limited to isolated pockets of residual gallery forest, even if this is the case, these populations will unlikely endure into the future (Penny *et al*., 2014). Further surveys are needed to search for this species elsewhere in northwest Madagascar; however, it is possible this species is now limited to Sahamalaza, along with the two other apparent local endemics *B. tsilomaro* and *C. berara* (Vences *et a*l., 2005, 2010; Glaw & Vences, 2007.

The population in Ankarafa Forest is restricted to two streams isolated from one another by habitat fragmentation; the stretch of savannah separating them will likely limit gene flow (Penny *et al*., 2014). Nearby areas of forest, both up- and downstream of *B. ankarafensis* habitat have been converted to *tavy* fields and are regularly cleared by burning. A single uncontrolled forest fire has the potential to damage all known areas of suitable habitat and this coupled with their severely limited range distribution means this species meets the criteria of Critically Endangered on the IUCN Red List (Penny *et al*., 2014) and will likely be evaluated as such in the near future. This species faces a severe risk of extinction and requires an immediate reprieve from habitat destruction. The feasibility of establishing a captive colony should be investigated. However, any future breeding project should only be undertaken if there is extreme confidence in success, as the removal of breeding individuals from such a small population (likely to number fewer than 250 individuals) could push this species even closer to extinction.

***Boophis brachychir* (Boettger, 1882)**

IUCN Red List Status: Data Deficient

Boophis brachychir (Fig. 4c) is a large, brown species of treefrog of the subfamily Boophinae, subgenus *Boophis*. Under the new definition of this taxon (Glaw *et al*., 2010), *Boophis brachychir* is known from its type locality Nosy Be (with precise localities Andranobe and Beomby), (2) Manongarivo Special Reserve, (3) Forêt d'Ambre Special Reserve, (4) near Antsiranana and (5) now also from Sahamalaza Peninsula (Table 1). Morphology and genetic data indicate that individuals are the same species as those identified from Nosy Be and (Glaw *et al*., 2010, A. Crottini personal observation). Individuals were found along streams in Ankarafa Forest but also from the bank of degraded stretch of river in Antafiabe village (Table 1), therefore it may cope relatively well with degradation and not be at immediate risk of decline. However, this species has a highly fragmented range and it will likely lead to this species being classified as Vulnerable in the near future.

***Boophis jaegeri* Glaw and Vences, 1992 Jaeger's Bright-eyed Frog**

IUCN Red List Status: Vulnerable (Andreone *et al*., 2008)

Boophis jaegeri (Fig. 4d) is a member of the subfamily Boophinae, subgenus *Boophis*. This species is listed as Vulnerable and populations are considered to be declining due to habitat

destruction (Andreone *et al*., 2008). *Boophis jaegeri* has a limited range distribution and is known only from a few sites across north-western Madagascar (Glaw & Vences, 2007). The species was infrequently encountered across the peninsula and only found within forested habitat (Table 1). Furthermore, these populations occur within fragmented habitat and those in Sahamalaza are isolated by a 20 km wide stretch of savannah and scrubland; for an arboreal frog this barrier will limit gene flow. Despite the discovery of the new population from Ankarafa Forest, its distribution does not increase significantly enough to warrant a change to its IUCN status. Populations on Sahamalaza are likely declining due to habitat destruction and all forest destruction must halt if this species is to be protected.

***Boophis tephraeomystax* (Duméril, 1853) Dumeril's Bright-eyed Frog**

IUCN Red List Status: Least Concern (Nussbaum *et al*., 2008)

Boophis tephraeomystax (Fig. 5a) is a medium sized, brown treefrog belonging to the subfamily Boophinae, subgenus *Sahona*. This species is widespread throughout Sahamalaza (Table 1) and across eastern and northern Madagascar (Glaw & Vences, 2007). The population in Ankarafa Forest represents the known south-westerly extent of this species' range. The species was abundant in Sahamalaza and found within heavily degraded areas. Populations are likely to be stable throughout Madagascar and as such this species is classed as Least Concern on the IUCN Red List (Nussbaum *et al*., 2008).

***Boophis tsilomaro* Vences, Andreone, Glos and Glaw, 2010 Spiny Bright-eyed Frog**

IUCN Red List Status: Not Evaluated

Boophis tsilomaro (Fig. 5b) is a member of the subfamily Boophinae and subgenus *Boophis*. Until recently it was only known from the Berara Forest fragment in Anabohazo Forest but the most recent survey identified a second population within the adjacent Ankatsekely Forest fragment. However, no individuals were detected from Ankarafa Forest - the only other significant area of forest on the peninsula. Other surveys in northwestern Madagascar (e.g., Manongarivo, Tsaratanana, Benavony) have failed to detect this species, despite its distinctive call; it is thus likely that it is restricted to Sahamalaza (Vences *et al.*, 2005; Glaw and Vences, 2007; Vences *et al*., 2010). Limited to such a small area, this species is at extreme risk of habitat destruction and meets the criteria of Critically Endangered (Vences *et al*., 2010). Its rarity makes it a candidate for an *ex situ* breeding programme. However, its breeding conditions may be difficult to replicate in captivity, as this species forms large aggregations of individuals following seasonal heavy rains (Vences *et al*., 2010). Reforestation schemes should be concentrated on the savannah and scrubland currently separating the two populations found in Ankatsekely and Berara fragments in Anabohazo Forest.

***Gephyromantis pseudoasper* (Guibé, 1974) Massif Madagascar Frog**

IUCN Red List Status: Least Concern (Andreone and Raxworthy, 2008)

Gephyromantis pseudoasper (Fig. 5c) is a member of the subfamily Mantellinae, and subgenus *Phylacomantis*. In Sahamalaza this species occurs within Anabohazo Forest (Table 1). The species was not detected from Ankarafa Forest despite the conspicuousness of its loud far-ranging calls. Anabohazo Forest appears to be the south-westerly limit of this species' range (Glaw & Vences, 2007) and it is possible that the slight differences in climate and biogeographical characteristics between the two forests make Ankarafa unsuitable for *G. pseudoasper*. Despite the distance only equalling around 20 km, any slight changes in humidity and temperature could be exacerbated by the greater levels of degradation found in Ankarafa. If this is the case then *G. pseudoasper* may be acting as a biological indicator of disturbance on the peninsula. If the selective logging and clearcutting within Anabohazo continues at the current rate, then it could be extirpated from Sahamalaza entirely in the near future. However, this species is designated Least Concern and occurs relatively widely across Northern Madagascar (Andreone & Raxworthy, 2008) so this should not be a major threat to the future of this species.

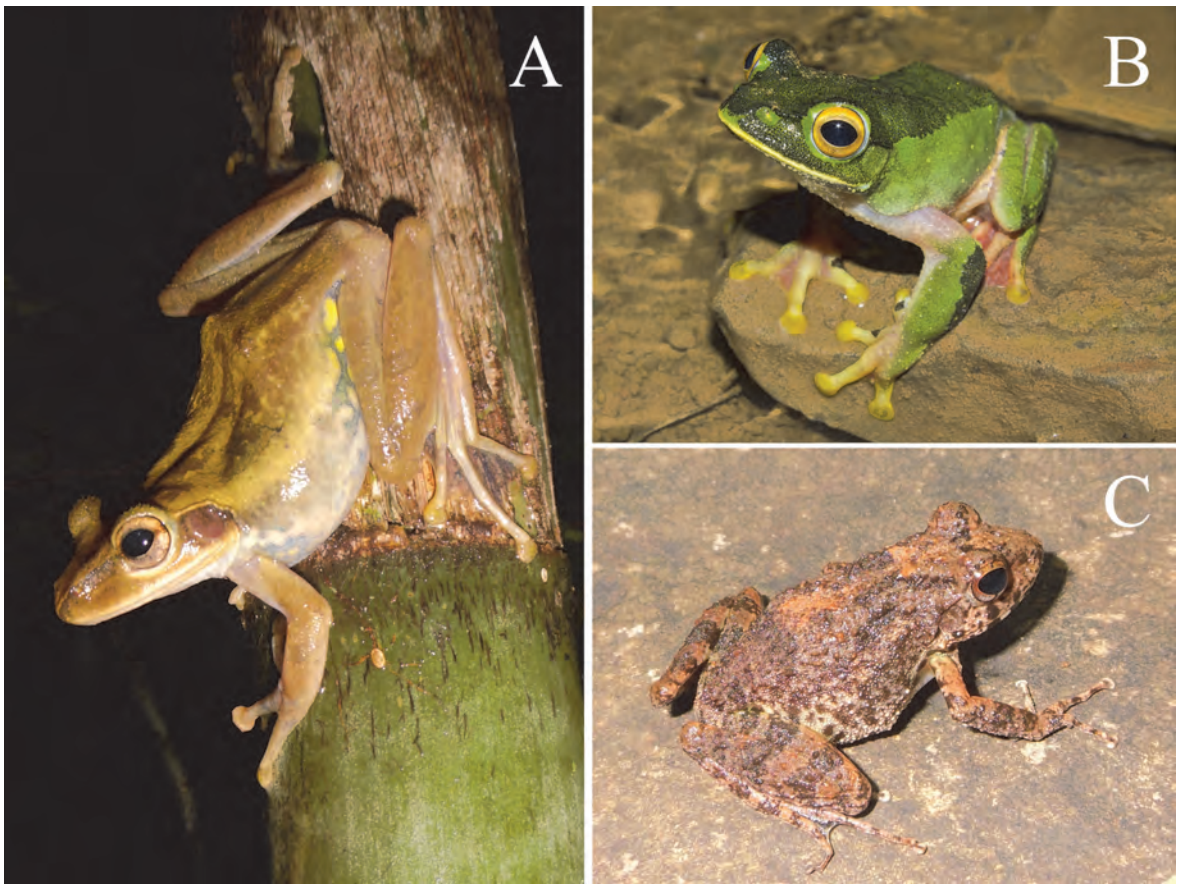

Figure 5: (A) *Boophis tephraeomystax* **(B)** *Boophis tsilomaro* **(C)** *Gephyromantis pseudoasper* (Photos: Samuel G. Penny [A, C] Gonçalo M. Rosa [B])

Laliostoma labrosum **(Cope, 1868) Large-lipped Madagascar Bullfrog**

IUCN Red List Status: Least Concern (Nussbaum *et al*., 2008)

Laliostoma labrosum is a largely terrestrial species that belongs to the subfamily Laliostominae. In Sahamalaza this species was previously detected from the Analavory

Forest (Table 1). Analavory has since been destroyed by fire (Volampeno, 2009) which means this population may have since been lost. Although undetected from the forests of Anabohazo and Ankarafa, it likely occurs elsewhere on the peninsula as it is known to cope well with high levels of anthropogenic disturbance (Nussbaum *et al*., 2008). Widespread across Madagascar and ranked as Least Concern its conservation is not a priority (Nussbaum *et al*., 2008).

***Mantella ebenaui* (Boettger, 1880) Ebenau's Golden Frog**

IUCN Red List Status: Least Concern (Andreone & Vences, 2008)

Mantella ebenaui (Fig. 6a) is a small but distinctly coloured species, belonging to the subfamily Mantellinae. In past surveys this species was classified as *M. betsileo*, but recent phylogenetic analyses on populations across Western Madagascar determined the population in Sahamalaza to be *M. ebenaui* (Andreone *et al*., 2001; Glaw and Vences, 2007; Rabemananjara *et al*., 2007). It remains impossible to distinguish any morphological, chromatic or acoustic distinction between the two species (Glaw & Vences 2007; Rabemananjara *et al*., 2007). It is ranked as Least Concern on the IUCN Red List and is likely to be widespread elsewhere on the peninsula, and so its conservation is not a priority (Andreone & Vences, 2008).

***Mantidactylus ulcerosus* (Boettger, 1880) Warty Madagascar Frog**

IUCN Red List Status: Least Concern (Nussbaum and Vences, 2008)

Mantidactylus ulcerosus (Fig 6b) is a semi-aquatic frog in the subfamily Mantellinae, subgenus, *Brygoomantis*. *Mantidactylus ulcerosus* was relatively common at most sampled sites on the peninsula (Table 1). The species is known from many protected areas outside of Sahamalaza, occurring throughout large parts of Madagascar, with populations only absent from the central plateau and arid southwest (Glaw & Vences, 2007). Currently it is ranked as Least Concern on the IUCN Red List but a taxonomic revision will most likely reveal that this taxon represents a complex of species so it may require a re-evaluation in the future (Nussbaum & Vences, 2008).

***Cophyla berara* Vences, Andreone and Glaw, 2005 Berara Whistling Treefrog**

IUCN Red List Status: Critically Endangered (Andreone and Vences, 2008)

Cophyla berara (Fig. 6b) is a relatively small sized treefrog in the subfamily Cophylinae. All records of this species are from the Sahamalaza Peninsula and it appears to be a local endemic. Prior to the 2011-13 survey this species was only known from its type locality: primary forest in the fragment of Berara in the larger Anabohazo Forest (Vences *et al*., 2005; Andreone and Vences, 2008). Following this survey, new populations were confirmed from Ankarafa Forest, the surrounds of Antafiabe Village, and Ankatsakely within Anabohazo Forest (Table 1). Furthermore, many individuals were found outside of primary forest within bamboo-dominated immature secondary forest.

In Ankarafa Forest past land clearances have created a matrix of interlinked forest fragments surrounded by large thickets of bamboo. *C. berara* was extremely abundant in these forest edge habitats and in interior sections where bamboo was present. It was detected in all surveyed fragments, including in isolated sections of heavily degraded forest that had recently experienced burning. However, despite these high abundances, it is unknown whether these small isolated populations will endure. Genetic data reveal that populations from Ankarafa and Anahabohazo have already slightly diverged, with two fix substitutions (at the mitochondrial 16S rRNA gene fragment analysed) indicating very limited gene flow between separated populations. Thus although the species appears relatively well adapted to disturbed forest, it is still a forest-dependent species and at risk from future habitat destruction.

Using current data this species continues to meet the criteria for the category of CR from IUCN Red List. This species clearly benefited from the initial creation of the park having colonised the newly vegetated areas resulting from the halt in farming. If human activity can be halted within the park the resultant natural regeneration of forests should lead to an increase in the population of *C. berara*.

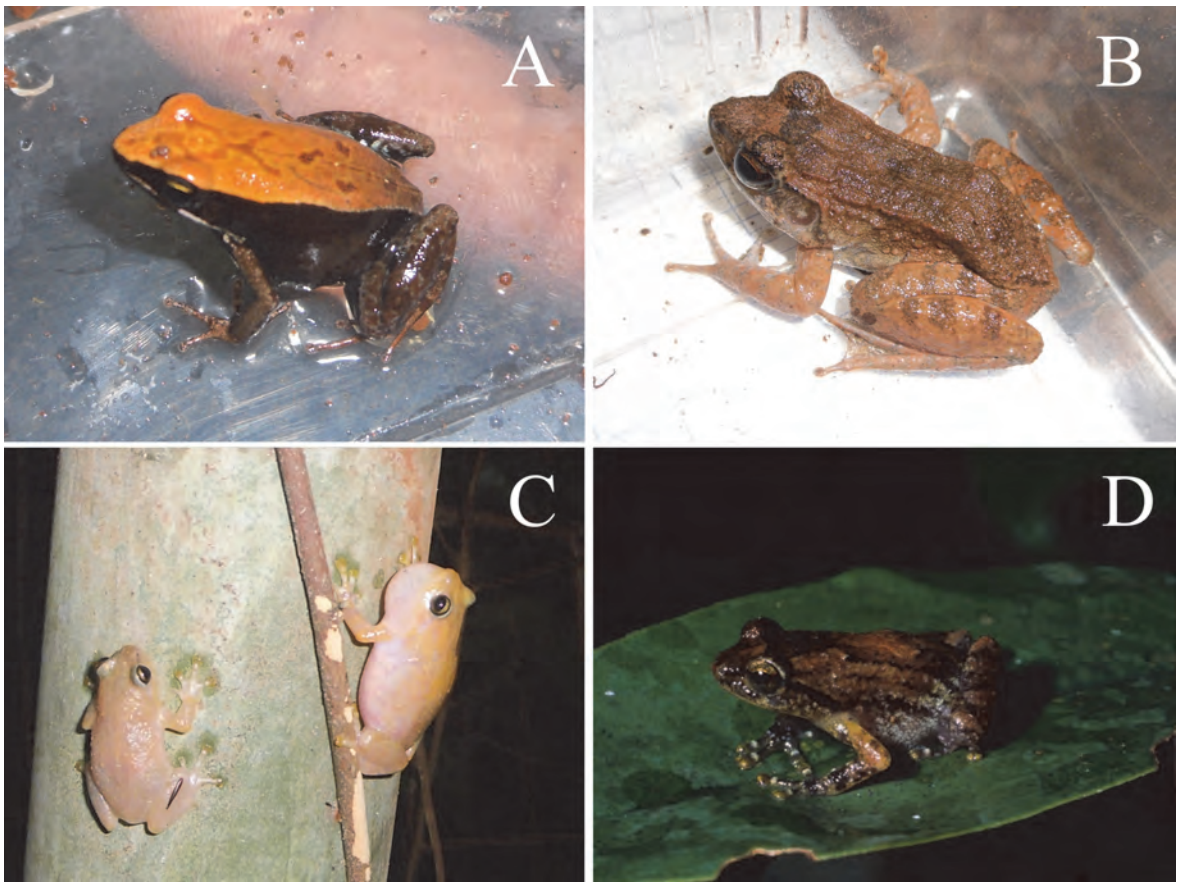

Figure 6: (A) *Mantella ebenaui* **(B)** *Mantidactylus ulcerous* **(C)** *Cophyla berara* **(D)** *Platypelis* sp. aff. *Cowanii* (Photos: Samuel G. Penny [A, B, C]; Franco Andreone [D]).

Platypelis* sp. aff. *cowanii* and *Rhombophryne* sp. aff. *alluaudi

IUCN Red List Status: Not Evaluated

During the original survey of Anabohazo Forest by Andreone *et al*. (2001) two species of Cophyline were encountered that morphologically matched no known species (Fig. 6d; Fig. 7a). One was preliminarily assigned to the genera *Platypelis* and the second to *Plethodontohyla* (or *Rhombophryne*). No frogs that could be attributed to these genera were detected during the recent field surveys at any of the sites surveyed on the peninsula, and thus Anabohazo Forest remains their only known location (Table 1). Data are still required to determine whether they represent a phenotypical variant of an already known species or one new to science.

Species of the genera *Plethodontholya* and R*hombophryne* are generally difficult to encounter in the field. The failure to locate this taxon during the most recent survey of Anabohaozo is likely explained by these secretive lifestyles. *Platypelis* species are generally easier to spot, however this conspicuousness can be limited to a short explosive breeding season (Glaw & Vences, 2007), which may have been missed during the comparatively short survey of Anbabohazo. On the contrary, the absence of these microhyids from Ankarafa is likely real as this forest underwent a far more exhaustive survey. Microhyliids are considered sensitive to microclimatic change (Vallan, 2000) and so this absence may reflect Ankarafa's higher levels of degradation. This highlights the urgency in bringing the human encroachment within these forests to a halt.

Microhylidae

***Stumpffia gimmeli* Glaw and Vences, 1992 Benavony Stump-toed Frog**

IUCN Red List Status: Least Concern (Glaw and Vences, 2008)

Stumpffia gimmeli (Fig. 7b) is a small species of Cophylinae. This frog was found throughout forested areas in Sahamalaza (Table 1) where it occurs in abundance within the leaf-litter. The species is common throughout its range across Northwestern Madagascar and ranked as Least Concern on the IUCN Red List (Glaw and Vences, 2008) and so its conservation in Sahamalaza is not a priority.

Stumpffia* sp. aff. *pygmaea

IUCN Red List Status: Not Evaluated

This frog is only known from Sahamalaza where it was detected from within intact forest in Ankarafa and Anabohazo during the most recent survey (Fig. 7c; Table 1). It has not yet been described but molecular data found only a 90% match (*p*-distance transformed into percent; at the 16S rRNA gene fragment analysed) with *S. gimmeli*, while the highest match was with S. *pygmaea* (92-93%) and so it clearly represents a new species that requires formal description. This species can be found within leaf-litter on the forest floor and its calls are relatively inconspicuous and difficult to locate. It is thus possible that this species has been

missed by other surveys and also occurs outside the peninsula. However, if this species does prove to be a local endemic it is likely to qualify as Critically Endangered due to its restricted distribution in a habitat at risk of destruction. The species was relatively abundant throughout Ankarafa Forest and so it should be possible to remove a number of breeding individuals to a captive breeding programme without significantly impacting the remaining population.

Ptychadenidae

***Ptychadena mascareniensis* (Duméril and Bibron, 1841) Mascarene Grass Frog**

IUCN Red List Status: Least Concern (IUCN SSC Amphibian Specialist Group, 2014)

*Ptychadena mascareniensis (*Fig. 7d) is a medium sized frog belonging to the family Ptychadenidae. It is widespread in Sahamalaza, with populations known from all surveyed forests and Antafiabe Village (Table 1). This species is widely distributed throughout Madagascar and the African continent and it copes well with human disturbed habitats (Rödel *et al*., 2009). *Ptychadena mascareniensis* is ranked as Least Concern (IUCN SSC Amphibian Specialist Group, 2014) and populations are unlikely to decline in response to the ongoing forest loss in Sahamalaza.

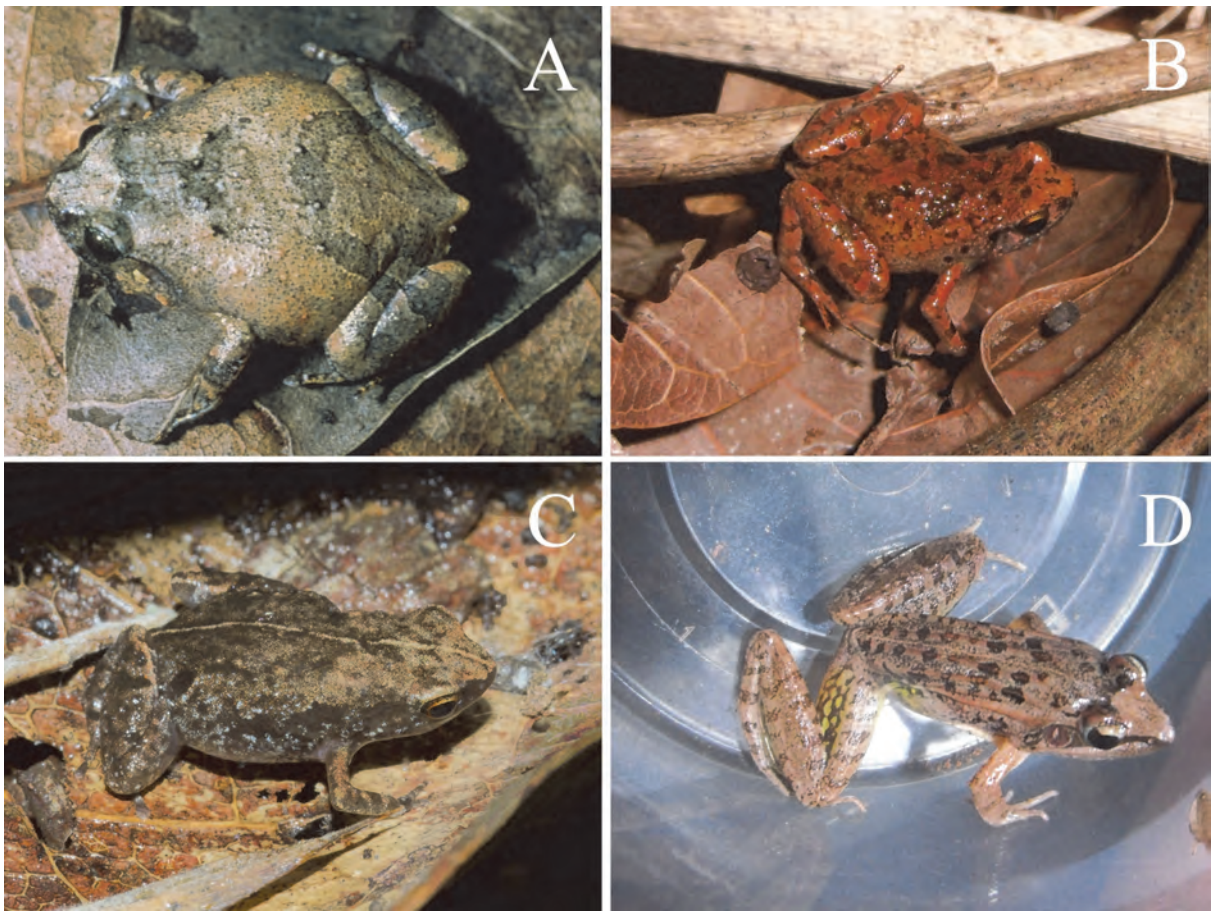

Figure 7: (A) *Rhombophryne* sp. aff. *alluaudi* **(B)** *Stumpffia gimmeli* **(C)** *Stumpffia* sp. aff. *pygmaea* **(D)** *Ptychadena mascareniensis* (Photos: Franco Andreone [A]; Samuel G. Penny [B, D]; Gonçalo M. Rosa [C])

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