PROJECT FINAL REPORT 2022
Project 36102-B
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Title: Intensifying efforts to rediscover and save the last mountain toads of Mount Bamboutos, Cameroon

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Mr. Idesse and Albert assisted with our community entry and meeting planning respectively in Fido and Banwa village. They also provided accommodation for the team members anytime we were near Babadjou township. We are also grateful to Mr. Philip, Abdou, Adji, Armand, Oumarou, Mrs Diane, Ernestine, Simone and several students and community members who participated in our field work and workshops.

Project Team

Dr Arnaud Tchassem Fokoua co-ordinates this project. He has recently received his PhD from the University of Yaoundé I researching the conservation biology of amphibians in the Bamenda Highlands, especially on Mount Bamboutos. Dr Tchassem Fokoua has recently won a postdoctoral fellowship with the MOPGA Program to undertake eDNA analysis to trace small populations of endangered frogs in the Highlands of Cameroon.

Dr Tasse Taboue has a PhD in wildlife management and ecology from the University of Buéa. He currently works at the Institute of Agricultural Research for Development, Ministry of Scientific Research and Innovation, Cameroon. He is currently the country director of EcoCaF.
As an ecologist, Dr Tasse has applied his skills and experience in analyzing the ecological data as well as the data generated from the questionnaire. He has been equally team leader of many conservation project focused on the biggest frog in the world - *Conraua goliath*, endemic to Cameroon. During the project, he has served as a field assistant for conducting research on amphibians in different habitats along the altitudinal gradient of Mount Bamboutos. His experience has been very important to our project, and has been very helpful in protecting the potential associated habitats.

Dr. Thomas Doherty-Bone is an ecologist researching conservation biology, management, and herpetology. Thomas is associated with the Royal Zoological Society of Scotland and the Natural History Museum, London, United Kingdom. In this current project, Dr. Doherty-Bone was involved in the supervision of the field survey, amphibian ecology, amphibian chytrid fungus and conservation and training for habitat assessment and mapping. He advised on the technical assistance for the laboratory works in the U.K.

Tsekane Sedrick (MSc) is a trained amphibian conservationist. Mr Tsekane is a graduate of Zoology at the University of Douala, and he has about six years of field experience involving ecological studies and biodiversity assessment. In this present study, he assisted in sampling, collection, and identification of amphibians and reptiles, in coordinating and supervising field surveys and initiating awareness-raising for amphibians.

Mr Mballa Ndzie is currently a second-year PhD candidate at the University of Yaoundé I, Cameroon. Mballa received his Master's degree at the same university, completing multiple research projects in ornithology. He helped in the coordination of the local team members.

Guides and porters (Seydou, Idrissou, Denis, Abdou) have served as excellent facilitators and guides because of their experience of the study site. They have also serve as translators during talks with farmers and shepherds.

Mr Ntene Soh is pursuing a PhD program on amphibian ecology and conservation the University of Buéa. He has participated regularly in field surveys, conservation education and outreach programmes, and coordinated data entry. During that period he participated in different community conservation education and awareness programmes both in local communities in Cameroon. Such experience has been very important in many aspects of the project including: conservation education programmes, outreach and awareness raising in the surrounding communities and capacity building.

Mrs Djouba Kenang is a trained conservationist. She is a graduate of Conservation of the biodiversity. She has a Bachelor of Sciences degree with specialized interest in nature photography. Djouba was the team photographer but due to some other commitment could not stay with the team for the entire project duration.

Introduction

Mount Bamboutos (MB) is the third tallest peak in Cameroon (2740m a.s.l.) and the largest, mountain chain at the median edge of the Cameroon Volcanic Line (Gountié et al. 2012). This mountain is very topographically and geomorphologically diverse and holds a high diversity of wildlife (Channing & Rödel, 2019). On MB, the status and distribution of amphibians are poorly known and their conservation has long been neglected. It is obvious that some species might have been lost or yet undocumented. MB has probably the highest rate of deforestation in Cameroon and the loss of the forest cover makes it urgent and important for the conservation of animals most especially the often-neglected amphibians. The density of endemic species has led to the designation of the site as an Alliance for Zero Extinction site. Despite this status, none of the natural habitats on Mount Bamboutos are officially protected. The mountain range has a high human population density, which has caused extensive habitat loss in the past. This could nowadays have caused the total extinction of these species in wild. Habitats have disappeared, have been reduced in size, or disturbed through various forms of agriculture (Tchassem, pers. obs. 2022). The remnant forest habitat on the mountain which is so critical to the frog's survival is undergoing rapid

conversion and degradation. Forest conversion and degradation is caused by unsustainable agricultural activities by local farmers such as intense shifting cultivation, and bush fires (Zephania, 2014). Disturbance by cattle in the frog's riparian habitat is causing soil erosion and further degrading the frog's breeding habitat (streams). More recently, amphibian declines on Mounts Manengouba and Oku (closest mountains to Mount Bamboutos) have been linked to the chytrid fungus that may be interacting with possible changes in climate (Hirschfeld et al 2016, Doherty-Bone & Gvoždík, 2017). Given to the presence of diverse, endemic and highly threatened species, some of which are unknown to science, knowledge of the frog's habitat requirement, threats, distribution and population is important to develop robust scientific intervention to save this species. Without this information, specific threats and their solutions cannot be evaluated, and conservation measures not accordingly planned and executed (Howard & Bickford, 2014). By facing the still fast ongoing deforestation in Central Africa in general and in Cameroon particularly, it is one of the most urgent targets to get more in more knowledge about forest dependent species and to define the conservation status of those forests that still remained.

Based on our findings, and facing the threats to the remaining local forests, we investigated several forested areas in Mount Bamboutos, with a major emphasis on the search for endemic and endangered amphibian species (e.g. *Wolstertorffina mirei* & *Werneria bambutensis*). The purpose of our survey was to rediscover and locate these very rare species, as well as to redefine their population status, especially for those amphibians that were never recorded again after 2009. Based on our findings, we secondly aimed to pursue conservation works engaged during our EDGE project concerning the investigated sites.

This work was conducted in close cooperation with the local population. One student (Branly NTENE SOH) has been trained in species identification and field techniques, now being able to help with future amphibian identification and monitoring.

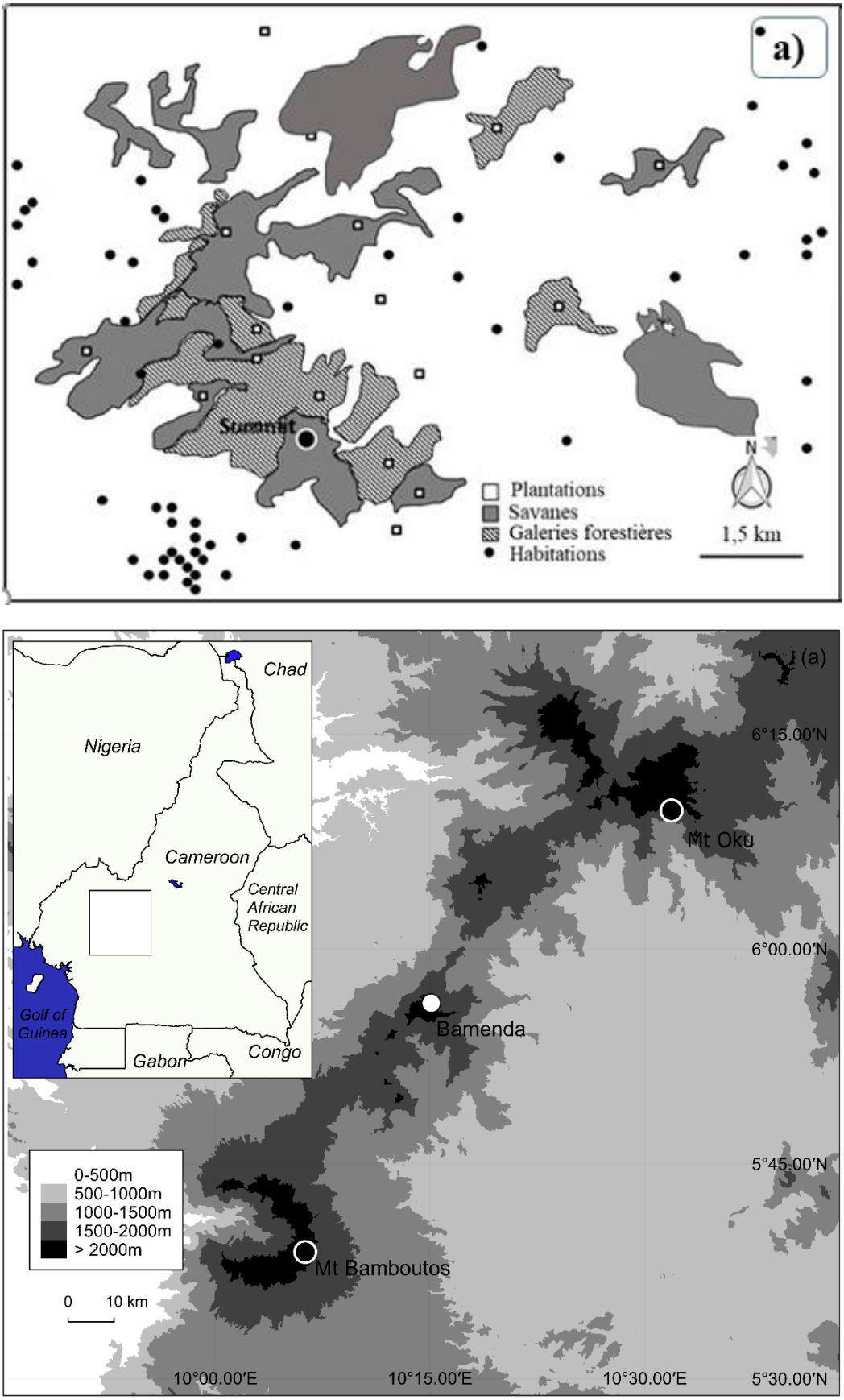

Figure 01: (a) location of survey sites on Mount Bamboutos; (b) Topography of the Bamenda Highlands

Aim and objectives

The project aimed to locate and preserving the remnant toad populations and at working towards habitat management and restoration in collaboration with the local community.

The work included:

- Undertaking focused surveys for *Werneria bambutensis* and *Wolterstorffina mirei* at higher elevations of Mount Bamboutos to identify possible remnant populations, assess threats, and characterize habitats for key areas of conservation priorities.
- Assess the presence/absence of chytrid fungus on the focal species and threats to the amphibian survival;
- Collaborate with local communities to protect and restore mountain forest through reforestation programmes;
- Reinforce local awareness of the species' conservation needs and sustainable use of natural resources to conserve the habitat of *W. bambutensis & W. mirei*.

1. Anthropogenic activities recorded

Pastoral space on Mount Bamboutos is constantly increasing to the detriment of natural habitats (Moudingo, 2007). Overgrazing and permanent farmer-herder conflicts are the most apparent signs of a strong land constraint for spaces and the degradation of natural resources (Moudingo, 2007). The significant need for cultivable land and the gradual increase in cultivated areas to the detriment of forests are gradually saturating the space, where even the steepest slopes are colonized (Moudingo, 2007). The main economic activity in these regions is agriculture, which occupies more than 80% of the active human population.

A polyculture system is generally practiced there in four annual cycles, where food crops (potatoes, carrots, cabbage, leeks) in places are often associated with annual crops (cassava) in a complex combination. The use of chemical and organic fertilizers to support the intensive use of plots is widespread (Moudingo, 2007). These chemicals are the cause of variable and harmful effects on entire populations of Batrachians, either by altering the central nervous system, or by causing adult sterility, as well as increased mortality in tadpoles (Relyea, 2004). Fallow was once regularly observed there and tends to disappear little by little.

Local communities consist of over 2000 people from various ethnic minorities, including Fulani (sometimes called Mbororo) and Mbouda. Land use on Mt. Bamboutos consists of forest patches, pasture, mixed farm, plantations, and exotic timber plantation (e.g., Eucalyptus) (Prinz & Rauch, 1987). Mount Bamboutos' forests suffer from intensive, uncontrolled farming has had negative consequences on biodiversity. There is no official habitat protection on the mountain.

METTHODOLOGY

Activity 1.1: ***Conduct fieldwork to detect target species presence/absence in eight forest patches on Mt. Bamboutos.***

To investigate the presence and identify priority areas for *Werneria bambutensis* and *Wolterstorffina mirei*, visual and acoustic encounter survey techniques were used to sample all suitable habitat types. Visual encountered survey included scanning of microhabitats such as underneath rocks and logs, peeling away backs, moving fallen debris and inspecting tree stems. Acoustic survey techniques involved the record of all calling males. Acoustic survey is useful in detecting the presence of frogs that are usually difficult to see such as the target species because of its small size. We listened to frog calls whilst conducting opportunistic visual searches in all suitable habitat types (Rödel & Ernst, 2004). Multiple calls coming from a single location was considered as a single male to avaoid double counting (Rödel & Ernst, 2004). Sampling was conducted by four people, moving along all defined transects during the day from 06:00 to 11:00 and at night from 19:00 to 00:00 recording observations of frogs, including abundance.

Frogs captured were temporarily held in sterile buckets containing sponges soaked with water until the end of the search and immediately released at the place of capture to minimize possibility of stress and desiccation. Strict disinfection of boots/shoes/clothes and all field work tools were applied when travelling between survey sites to prevent further spread of pathogens using Virkon or bleach.

Figure 02 : (a) Main team research Dr Tchassem (left), Ntene Soh & Junior Kansa (PhD students), Denis (One of our guide), Dr Tassé Taboué (extreme right);

(b) Dr Thomas DOHERTY-BONE providing guidance in the field; (c) Camping at the summit of Bamboutos

Figure 03: Dr Tchassem looking for toads in a probable breeding site.

Characterizing target toad's habitat

To characterize the habitat we identified ten rectangular plots 25x10m along each of the transects. In each plot, we collected habitat data on substrate/soil type, leaf litter depth and coverage, vegetation density and canopy coverage following the methodology used by Hillers et al., (2008) and Ernst and Rödel (2004). These data have been collected at 20 randomly selected points within the plots and corresponding data averaged for the whole plot.

Litter depth were measured to the nearest centimeter (Ernst and Rödel 2004). Canopy cover were measured at 0.3m above ground level using a concave densiometer. Number of woody plants were measured in defined different stem diameter at breast height (dbh) in four categories in order to stratify the vegetation around the study site (dbh1 =0–5 cm, dbh2 =6–10 cm, dbh 3 =11–20 cm and dbh 4 = 21–50 cm).

Measurements at the site scale such as temperature and humidity, as well as stream speed, width, depth, turbidity, and pH have also been carried out. Streams widths and depths were measured using a ruler or tape measure, water temperature and humidity has been measured using a thermometer and a hygrometer, respectively. pH measured using pH conductor, and turbidity measured using a handheld turbidity probe.

Description of research areas

Research areas were chosen so that most of the habitats of Mount Bamboutos were covered. This way species composition compared and it was possible for one person to visit them all the same amount of times in the research period.

These include:

-Eucalyptus

The area consists of introduced vegetation (IUCN, 2004) and measures approximately 800m x 1750m at around 2375m a.s.l.. The area is situated between three Fulani family's settlements, grassland and a main road. Ground vegetation is very limited; scrubby grass of max 20cm. Eucalyptus is known as using much water and therefore the ground is dry. Disturbance: Eucalyptus is a non-native species in Cameroon in general.

-Potato farms

The area consists of planted potatoes belonging mostly to indigenous peoples and also to Fulani who are mostly cattle herd men (pers obs, 2022). These crops are harvested three times a year

between March and September. Each Parcel measures approximately 25m x 55m with sometimes more than three pipes that ensures irrigation from small streams located upstream at 2650m a.s.l.. The parcel are separated each other on one long and short side, a small roads.

-Secondary forest

The area consist of secondary forest which is approximately 25 years old. The area is approximately 8m x 35m maintained by a low-speed water stream of about 15cm deep. There are several small clear water ponds surrounded by scrubby vegetation like muddy areas. Forest galleries identified have high trees including Bamboutos (>10m: 30%); trees (>7m: 35%) Shrubs and ground vegetation sometimes not more that 1.5m height (35 - 40%)

-Grassland

The area consists of very large pasturelands that could measure in average approximately 2000m.sq. This vegetation found there consisting of grass and sometimes reed. The grassland is grazed by cows, but the grass grows up to 25cm.

Figure 04: (a) Equipment for water quality analysis; (b) Oscar Nyingchia collecting data in the field

Figure 05: (a) Equipment for environmental data

Disease surveillance

All frog species encountered were sampled for *Batrachochytrium dendrobatidis* (*Bd*) to assess the presence and possible impact this pathogen may be having on the local frog population. Frogs were sampled with rayon-tipped swabs, with five swabs each of the underside of feet, limbs and pelvic patch (a total of 25 swabs per individual).

These swabs were subjected to real time PCR assay (Boyle *et al.,* 2004) with prevalence and infection intensity estimated. This was carried out at the Department of Life Science of the Imperial College London with supported from Synchronity Earth..

Figure 06: (a) Dr Tchassem swabbing frogs in the field; b) samples ready for shipment to laboratory.

Biosecurity **-** Field work was carried out respecting and adhering to biosecurity measures to prevent the spread of harmful organisms. This involved checking, cleaning and drying all equipment between field sites.

Education and Outreach of students and other stakeholders

An environmental awareness campaign about the importance of the amphibians in general on the mount Bamboutos has been carried out. This campaign has been done in Fido village, the main community where farmers exploiting the mountain are coming from. We pre-evaluated the level of knowledge of the population concerning importance to protect amphibians through a structured questionnaire developed and passed within the populations before the beginning of the project.

One conservation talk has been given to one primary and one secondary school

Figure 07: (a) Discussion with community leaders in Fido village and collecting suggestions; (b) Awareness raising in secondary schools in Babadjou ; (c) Delimitation of areas to restore in collaboration with locals

With the collaboration of locals, we demarcated areas where trees have been planted, areas have been lined out. A mixture of *Prunus africana, Cola acuminata* and *Persea americana* trees and saplings were planted during rainy season. These species previously occurred here and planting is aimed at providing a migratory riparian corridor whilst improving habitat conditions.

The conversion of suitable habitat is a major threat for the endemic amphibians population on Mount Bamboutos.

Around the mountain, population growth is high and pressure on land is increasing. Shepherds are burning down secondary forests for favoring the Savana regeneration where herbs constitute the main base food for cattle herds, farmers do it for the cultivation of corn. Swamps, ponds, and mountain shallow creeks are drained and used in potatoes, carrots, and cabbage fields. Especially this loss of shallow wetlands is affecting the endemic amphibian population. These amphibians need well-preserved areas, which offer suitable hiding places against predators and easy prey. Over these recent years, some streams have rapidly disappeared as farmers reclaimed wetland areas. As a result, the natural recruitment of the very rare amphibians restricted to mount Bamboutos is minimal, and their populations seem not recovering.

To facilitate the recovery of the species we are restoring critical nesting habitats. Access to seven precise locations including existing breeding areas has been limited to people. These areas are known as sites where the species have been historically observed.

By creating optimal habitat conditions for these very rare toads on mount Bamboutos, we attempt to re-enforce their populations. These efforts are closely monitored to determine their effectiveness. In the coming years, we will be able to assess whether and how this habitat restoration strategy could offer possibilities for replication in other areas in Cameroon.

Figure 08: (a) Lining and digging holes; (b) Areas with trees planted; (c) A *Prunus africana* tree planted; (d) Forest galleries known as breeding sites of *L. axillaris L. perreti, C. oreas, Wo. Mirei* and *We. mirei*

Figure 09: Local workers removing herbs around trees planted

eDNA sampling

To detect the presence of remnant populations of *Werneria* and *Wolterstorffina*, water samples were collected from forest streams to conduct environmental DNA analysis. A total of 80 water samples of 100ml at different points along each mountain stream known to be breeding sites were taken. After each sample, water was expelled through a single-use filtration unit containing a low porosity (0.45µm) polyethersulfone filter, which captures eDNA on the filters. Once the samples were completed, 50ml of buffer was added to the capsule to preserve the DNA. The capsules were then closed, shaken, then stored in the freezer to be later analyzed at the Laboratory of Ecology, Genomes, Behavior and Evolution of the National Center for Scientific Research (NCSR) – ("Institut Diversité Ecologie et Evolution du Vivant") in Paris. This is part of a postdoctoral fellowship of Dr

Tchassem as part of the MOPGA grant carrying out at the moment in the same institution under the supervision of Dr Nicolas Pollet.

Figure 10: Dr Tchassem at the Laboratory of Ecology, Genomes, Behavior and Evolution of the National Center for Scientific Research, France

Starting from the collection of the opinions of the people concerned by the decline of the batrachofauna then passing through concrete studies including sampling in the field. It will be a question of carrying out non-invasive genetic analyses from water samples containing traces of DNA from populations of very rare endemic amphibians; to confirm the presence or disappearance of these species that have not been observed for nearly a decade.

Figure 11: Dr Tchassem collecting water samples for environmental DNA Analysis

More specifically, it is about:

1. Develop genetic tools to identify these different species along the volcanic line of Cameroon, in order to obtain genetic sequences to set up monitoring by an environmental DNA approach.

2. Create an interactive map from this tool on a national scale with the aim of enhancing the data obtained by the environmental DNA method, in the form of 15 km by 15 km grids.

3. Study the physico-chemical characterization of the different streams; including micropollutants, waterborne pathogens and amphibian communities also in synergy with climate change.

4. Determine the limits of the range of these species by following an altitudinal gradient; since distribution maps of species that exist, but at different geographical scales, are not very up to date, hence the environmental DNA method.

5. Establish the mitochondrial genome of the species most threatened with extinction.

OUTPUTS AND RESULTS

Species richness

During this project, no individuals of *W. bambutensis* nor *W. mirei* were observed. A total of 79 specimens d nine species of anuran were recorded during the period of the project (Table I). These are the families Arthroleptidae (7 species), Bufonidae (1 species), Ptychadenidae (1 species), (Table I). The Arthroleptidae family was the most represented with more than half of the species observed: *Arthroleptis* cf. *perreti*, *Astylosternus ranoides, Astylosternus rheophilus, Cardioglossa oreas, Leptodactylodon axillaris, Leptodactylodon perreti* and *Leptopelis nordequatorialis*. Those of Bufonidae and Ptychadenidae were respectively represented by *Sclerophrys maculata* and *Ptychadena mascareniensis*.

Habitat requirements

All species recorded are known to depend on water to realize their breeding and tadpole development. However, each of these species can present different habitat preferences. Amphibians have not been recorded uniformly at the same moment. Based on studies carried out by Hirschfeld et al., 2012 & Doherty-Bone, 2015, toads are frequently associated with streams and savannas that they can share with cows. As well, I have surveyed Mt. Oku and Bamboutous during your PhD studies and never seen them.

Tadpoles have been mostly observed aggregating in shallow water. The toads' affinity for gallery forests where they breed on Mt Bamboutos may also be a consequence of hibernation requirements.

Surveys have been almost as much carried out in gallery forest than in agricultural and savanna habitats. Sites likely to harbor the toads have also been intensively surveyed. The majority of the species recorded were exclusively related to forest habitats (22.22%; 2 species), they are *Leptodactylodon axillaris, Leptodactylodon perreti*. *Arthroleptis* cf. *perreti*, *Leptopelis nordequatorialis, Sclerophrys maculata* and *Ptychadena mascareniensis* have been found only in agricultural areas (44.44%; 4 species). *Astylosternus ranoides, Astylosternus rheophilus, Cardioglossa oreas,* although being forest species seem to be resilient to anthropogenic activities (33.3%; 3 species). They have been found both in gallery forests and in agricultural areas. *Ptychadena mascareniensis* showed a high preference for savanna and farming habitats and are not normally occurring in primary forest situations.

All species with at least Vulnerable conservation status are endemic to Cameroon and occur exclusively on a few peaks (two, three or four) of the volcanic line, with extremely low altitudinal ranges; and where their situation is all the more severe than on the Bamboutos mountains. We refer to *Astylosternus ranoides* (EN), *Astylosternus rheophilus* (VU), *Cardioglossa oreas* (EN), *Leptodactylodon perreti* (EN). *Leptodactylodon axillaris* is locally endemic to the Bamboutos

Mountains and has only been found in three nearby forest galleries preserved by the force of conservation measures initiated during our previous projects on the site.

We believe that strengthening the program of restoration of natural habitats on this mountain committed to the EDGE project and supported during my Booster RSG Grant is an imperative. In the long term, it is possible that the regeneration of natural habitats promotes the recovery of remnant populations of these rare toad species, should any still occur.

Abundance

Among the 9 species of Batrachians observed, *Leptodactylodon perreti* was the numerically most abundant species with approximately (53%) of our entire sample, followed by the species *Astylosternus rheophilus* (18%), *Leptopelis nordequatorialis* (12%), *Ptychadena mascareniensis* (7%), *Astylosternus ranoides* (4%). The species *Leptodactylodon axillaris* (3%), *Cardioglossa oreas* (1%), *Sclerophrys maculata* (1%) and *Arthroleptis* cf. *perreti* (1%) were the least represented. The mountain's overall batrachofauna was also dominated by a single species. *Leptodactylodon perreti*, forest specialist. *Sclerophrys maculata* and *Ptychadena mascareniensis*, savanna specialists can be described as ubiquitous.

Eight (8) species (*Astylosternus ranoides, Astylosternus rheophilus, Cardioglossa oreas, Leptodactylodon axillaris, Leptodactylodon perreti, Leptopelis nordequatorialis* and *Ptychadena mascareniensis*) have been identified in the gallery forests. *Arthroleptis* cf. *perreti, Astylosternus ranoides* and *Sclerophrys maculata* have been observed in the savannas. *Astylosternus ranoides, Leptopelis nordequatorialis, Sclerophrys maculata* and *Ptychadena mascareniensis* in farms.

Although *Cardioglossa oreas* was observed during this study on Mount Bamboutos, *Cardioglossa pulchra,* a species taxonomically close to it, was not observed there. This is also the case for the mountain toads *Sclerophrys villiersi, Werneria bambutensis* and *Wolterstorffina mirei,* which are endemic to this mountain. The causes would also be different, another explanation given to justify the decline of these species on Mount Bamboutos would be of a health nature with the discovery of the *Batrachochytrium dendrobatidis* fungus on Mount Oku (Doherty-Bone et al., 2013). Mount Bamboutos would not be spared by this fungus due to its proximity to Mount Oku. This pathogen has been known in Cameroon since 1934 in the eastern and southern regions (Soto-Azat et al., 2010); which indicates that if it is involved in the decline of the Batrachians, it would be through recent changes in environmental conditions which would favor its dispersal.

It is possible that many species disappeared from Mount Bamboutos before the start of the first biological field expeditions. *Werneria bambutensis* and *Wolterstorffina* mirei have not been

collected from Mount Bamboutos for over a decade. It also seems that the conservation assessment of toad species is raised to a more severe risk of extinction. The absence of these species in our sample would be due to the very strong dependence of tadpoles and adults on their living environment and their high sensitivity to grazing and chemicals used in agriculture.

A total of 143 people were interviewed individually in two villages selected. Rapid rural appraisal methods (RRA) (Chambers 1981, Polidoro et al. 2008, Sattout et al. 2008) were used; interviews were conducted using a semi-structured survey form. Forty-five (45) questions were asked to each participant: five questions about personal information (origin, age, sex, and background); four questions on their occupation; ten questions respondents' general knowledge of target species, the influence of forest degradation on amphibian diversity, and on the potential use of these amphibians to trace the disruption level of forests due to human activities; nine questions on conservation actions to implement in the field.

-The interviews included questions such as: what basic problems do they have?; What makes farming difficult for them?; Which crops are easier to grow and why?; Have they been confronted with water issues?; How do they organize themselves to share the lands?; What pesticides do they use?; For how long on average do they exploit the mountain? Were passed in the nearest village, through different groups (farmers shepherds, women, and other members of the community). Interviews were conducted in a single community that is the closest to the project area and constitutes the only community that exploits natural resources from mount Bamboutos. Based on the information generated from the local perception, we developped an adequate tailored sensitization strategy with well-targeted messages during the next awareness and education campaigns. Brochures with amphibians conservation and sensitization messages produced and distributed around the villages in a very accessible language has been adequately detailed and simplified in order to reach more at all levels of the community.

DISEASE

None of the samples screened for amphibian chytrid fungus were found to be positive based on diagnostic real time PCR assays. This is possibly due to most of the species sampled being *Leptodactylodon* sp., which are probably not competent hosts for this pathogen. It had been noted that on other mountains, this genus do not disappear and have low prevalence of this pathogen. It is possible that with other more susceptible host species declining (for whichever reason, such as habitat loss, climate, or even infection), the pathogen itself will decline and be less common. This was also a relatively small sample size of less than 50, indicating the pathogen is not absent but at low prevalence. While the samples were stored in vials with ethanol, it is still possible that the DNA was degraded during transport through hot areas of Cameroon. *Batrachochytrium dendrobatidis* has previously been recorded to

Bamboutos but at low prevalence (Hirschfeld et al 2016). As this pathogen is also known to Cameroon since the 1930s, it is unclear whether it acts as an ultimate threat to amphibians on Bamboutos, though the speed of declines on this and other mountains show a similar rate to confirmed *Bd*-induced declines elsewhere.

THREATS TO AMPHIBIANS

Human threats to the distribution and habitat of Batrachians on the Bamboutos Mountains are very varied and mainly concern deforestation through the perpetual trampling of cows, bush fires, chemical pollution and agriculture. Habitats on Mount Bamboutos appear to have been converted mostly to agricultural plots and heavily polluted from intensive use of a wide range of pesticides, fertilizers and herbicides. The practice of agriculture is highly developed there. Deforestation, overgrazing and bush fires lead to severe and sometimes irreversible changes in microclimatic conditions; compaction and erosion of the soil, however disadvantageous for terrestrial Batrachians whose development is conditioned by a natural, thick and humid litter.

Figure 08: (a) Potato farms; (b) Burning of savannas to renew grasses during the dry season; (c) Examples of agrochemicals used by farmers on mount Bamboutos; (d) Cattle herd observed at around 2500 m a.s.l.
(N.B. the summit is at 2700 m a.s.l.)

ACHIEVEMENT

This project aimed at locating remnant toad populations and work towards habitat management and restoration in collaboration with the local community around Mount Bamboutos. We have not managed to collect an adult of *Werneria bambutensis*, nor *Wolstertorffina mirei*. Detailed knowledge of the ecology of *Werneria bambutensis* and *Wolstertorffina mirei* however remains very limited. We also further show that the amphibian assemblage present on Mount Bamboutos is unique in that it harbors an unusual composition of endangered Central African endemic frogs in large numbers.

A total of 1-hectare degraded land including six patches has been abandoned by farmers to restore the endemic and endangered frogs 'habitats in response to the threats they are facing, documented from this project. These areas are concentrated along small mountain streams where frogs are known to breed and live. The establishment of the replanted area will contribute to sustain the only remaining intact habitats as well as the target toad species and other endangered animals on the site. These realizations constitute an important contribution to the project's aim of improving the conservation status of these critically endangered toads. The land use is managed and will continue to be by us in collaboration with the local communities and local NGOs,s to benefit both wildlife and the people.

During this project, which makes me most proud is the feeling of having accomplished something great concerning the conservation of the most sensitive and fragile Cameroonian amphibian species. My project is the first-ever and the most important conservation project established on Mount Bamboutos concerning vertebrates.

Results collected from the project are likely to be used for prioritization and long-term management planning of mountainous natural resources in Cameroon. The findings of our study have as well provided the foundation on which the measure the impact of human activities (logging, farming, grazing, used of pesticides) on mountain amphibians before any target actions can be undertaken. As well, this has set the baseline for future development of long-term monitoring program based on distribution sites. This is necessary to understand and set in place a human land-use strategy in the area.

PROBLEMS FACED DURING THE PROJECT

Behaviour change and general community engagement programs worked very well during the project given that the population is constituted of Muslims who are mostly shepherds and Christians who are mostly farmers. This is because we took advantage of the religious inclination of the target communities by integrating our conservation awareness into the people's religion. We

remarked that this approach to conservation triggered a lot interest in our campaigns resulting in significant behaviour changes

FUTURE PLANNED WORK

This work will continue by focusing in two key areas. First, we will seek continuous funding to sustain behaviour change outcomes in the local community by providing to the people skills to sustainably use land on Mount Bamboutos. Second, we will reinforce the restoration of riparian habitats with the possibility of providing an alternative water source for the local community aimed at reducing human impact on the frog's habitat.

Around Mount Bamboutos, we will further seek to intensify training of local stakeholders of the project to maintain a conservation spirit within the community through generations and initiate a protection status to Mount Bamboutos; to establish a permanent conservation presence by establishing a programme involving youths, farmers, women in Fido village to aid conservation education efforts, implementation of conservation measures as well as population monitoring.


a)


b)


c)


d)


e)


f)


g)

Figure 10: Amphibians and associated species recorded during sampling on Mount Bamboutos.
[a) Green Tree Snake *Philothamnus* sp., a likely amphibian predator; b) *Leptodactylodon perreti*; c) *Leptodactylodon axillaris*; d) Tadpoles to identify; e) *Astylosternus ranoides* ; f) *Astylosternus rheophilus ;* g) *Cardioglossa oreas* ; h) Tadpoles of *Leptodactylodon* sp. ; i) Thomas Doherty-Bone taking environmental parameters on Mt Bamboutos; j) New breeding sites identified; k) Arnaud Tchassem looking for toads.

CONCLUSION

Remnant populations of *Werneria* and *Wolterstorffina* were not successfully located on Bamboutos, especially at the higher elevations where new surveys were set up. This raises the possibility of local extinction at this site, or even total extinction as they have not been found on the neighbouring Mount Oku for over a decade. Habitat degradation and loss may have been a factor, but disease and climate change are possibly a factor too and require further information. The project has otherwise greatly improved the understanding of local threat, habitat selection, home range, movement, and other ecology features of endemic and endangered amphibian species. This information is also crucial for in-situ conservation about ecology and microhabitat of some species which these knowledges are totally unknown (Hirschfeld et al. 2016). Therefore, detailed recommendations have been provided to the

protected area management board for an effective protection of the species in the wild. For that, we have mostly collaborate with the Ministry of Forestry and Wildlife (MINFOF). In particular Mount Bamboutos has gained more in international and national exposure as a result of this project; this has contributed definitely to increase conservation efforts at this site and consequently guarantee the persistence of this very fragile frog. The project has enhanced local capacity to conserve the target species. Local communities and graduate students and who started to be equipped with both information and skills to help efficiently to the management of frog species in general.

RECOMMENDATIONS

Mount Bamboutos is placed neither under official protection status nor under any conservation action. To improve the future prospects of the Batrachians of the Bamboutos Mountains, it is necessary to rely on adequate conservation interventions. This also and above all requires special attention from the public authorities through their effective involvement, as well as that of all stakeholders in conservation projects. The following recommendations are intended to contribute to the long-term preservation of endemic amphibians in general.

- options for reducing the rate of deforestation of Monts Bamboutos could be explored such as reducing the use of bush fires on the mountain;

- an Ex-situ conservation program for rare species (in this case *Werneria bambutensis, Wolstertorffina mirei*) for rearing and releasing toadlets to restored habitats as part of a co-ordinated program..

- better understand the lifestyles and ecological requirements of species in their respective habitats in order to consider breeding in captivity with the aim of carrying out reintroductions into the natural environment should be initiated around each site to support the most fragile and those of critically endangered species;

- greater awareness of breeders and farmers living around the Bamboutos Mountains, with the aim of drawing their attention to the impact of their activities should be regularly organized. These efforts aim to limit the burning of natural habitats by the Mbororos settled on the mountain;

- frequent awareness raising on the sustainable management of natural resources should be initiated for the youngest children in primary and secondary schools around these sites in order to create in them a spirit of biodiversity conservation from an early age;

- training workshops on making compost should be organized around Mount Bamboutos for farmers with the aim of diverting them or limiting the intensive use of chemical fertilizers on this site;

- the diversification of alternative income-generating activities for the local populations living around the Bamboutos Mountains should be encouraged in order to reduce the dependence of these inhabitants on the natural resources of the mountain. These are among others: the promotion of ecotourism and agroforestry;

- prevent any further encroachment, illegal logging and farming activities in all remaining forests.

- the protection of the remaining gallery forests of Mount Bamboutos through the creation of buffer belts of about 200 m in width around them is necessary;

- access restrictions to various strategic places of Mount Bamboutos should be established in order to limit the human disturbances experienced by certain breeding sites; This would help to reinforce the natural reproduction of these animals on this site;

- conduct regular monitoring on the persisting populations of particular frog species, especially focusing on the threatened or rare and endemic species, i.e. *Leptodactylodon axillaris, L. perreti, Cardioglossa oreas, Astylosternus ranoides, A. rheophilus* to assess how stable the populations are at different locations. For very rare amphibian species like *Werneria bambutensis* and *Wo. mirei*, this monitoring should not only focus on the areas where thes species were historically known, but also on the whole mountain;

The State should promote, encourage and assist the populations in the creation of community forests which present themselves today as an important bulwark for these animals. The example of "Kilum-Ijum" on Mount Oku should be reproduced on the Bamboutos Mountains in order to promote the conservation of local biodiversity.

Tableau I : Conservation status (IUCN) and geographic distribution of known Batracians on the Bamboutos

Species	**IUCN Statut**	**Endemicity**	**Sources**
ANOURA Arthroleptidae			
Arthroleptis cf. *perreti* Blackburn, Gonwouo, Ernst & Rödel 2009	EN	**Mt. Bam**	Observations personnelles
Arthroleptis cf. *variabilis* Matschie 1893	LC	**Mt. Bam**	Matschie, 1893 ; Observations personnelles
Astylosternus ranoides Amiet 1977	EN	**Mt. Bam**	Amiet, 1977 ; Personal observations
Astylosternus rheophilus Amiet 1977	VU	Cam+Ng	Amiet, 1977 ; Hirschfeld *et al.,* 2016 ; Personal observations
Cardioglossa oreas Amiet 1972	EN	**Mt. Bam**	Amiet, 1972 ; Personal observations
Leptodactylodon axillaris Amiet 1971	CR	**Mt. Bam**	Amiet, 1980 ; Hirschfeld *et al.,* 2016; Personal observations
Leptodactylodon perreti Amiet 1971	EN	**Mt. Bam**	Amiet, 1971 ; Personal observations

Leptopelis nordequatorialis Perret 1966	LC	**Mt. Bam**	Gartshore, 1986 ; Personal observations
Bufonidae			
Sclerophrys maculata Hallowell 1855	LC	**Mt. Bam**	VG 2005 ; TMD-B. 2006, Non published data
Sclerophrys villiersi Angel 1940	EN	**Mt. Bam**	VG 2009,
Werneria bambutensis Amiet, 1972	CR	**Mt. Bam**	Amiet, 1972 ; TMD-B, 2006,
Wolterstorffina mirei Perret, 1971	EN	**Mt. Bam**	Personal observations; Nyingchia & TMD-B 2012, Non published data
Ptychadenidae			
Ptychadena mascareniensis D & Bibron 1841	LC	**Mt. Bam**	Personal observations TMD-B, 2006, 2009,
GYMNOPHIONES			
Herpelidae			
Herpele squalostoma Stuchbury 1836	LC	CongB	Tchassem *et al.,* 2021

Abréviations : CR – (Critically Endangered) ; **EN – (**Endangered); **VU – (**Vulnerable); **NT – (**Near Threatened); **LC – (**Least Concern); **TMD-B: –** Thomas Michael Doherty-Bone; **V.G –** Vaclav Gvoždík; **CongB: –** restreintes au Bassin du Congo; **S-Sa: –** Aire de répartition (Afrique Sub-Saharienne); **BamH: –** Espèces restreintes sur les Bamenda highlands; **Cam+Ng. –** restreintes aux montagnes du Cameroun et du Nigéria ; **Mt. Bam : –** restreintes (endémiques) au mont Bamboutos ; **P.Af.c+Af.o +Ng: –** restreintes aux montagnes des pays d'Afrique Centrale, de l'Ouest Cameroun et au Nigéria: **P.Af.c: –** restreintes au montagnes des pays d'Afrique Centrale. **P.Af.c+Af.o: –** restreintes aux montagnes des pays d'Afrique Centrale et d'Afrique de l'Ouest: **P.Af.c +Ng**: **–**restreintes aux montagnes des pays d'Afrique Centrale et au Nigéria.