Biodiversity surveys of Mariarano and Matsedroy tropical dry forests and associated wetlands, Western Madagascar

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Final Report

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Operation Wallacea
Conservation research through academic partnerships

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Development & Biodiversity Conservation Action for Madagascar

Introduction

The Mahamavo region in Western Madagascar contains relatively large blocks of intact western dry forests and wetland ecosystems. A consortium comprising Development and Biodiversity Conservation Action for Madagascar (DBCAM), Operation Wallacea and the University of Oxford has been conducting a programme of biodiversity surveys and monitoring in this area since 2010. DBCAM is a grass-roots Malagasy conservation NGO, Operation Wallacea is an international volunteer-based NGO which supports conservation research through academic partnerships and The University of Oxford is a research intensive university.

The Mahamavo region has received relatively little study, yet supports considerable biodiversity including globally threatened flowering plants, reptiles, birds and mammals. Flagship species in the area include the Madagascan Fish Eagle, Coquerel's sifaka and Angel's and Oustalet's chameleons. Forests in the area are currently threatened by fires, charcoal production and agricultural expansion.

This project is a landscape-scale long-term monitoring programme of multiple taxonomic groups. The aims of the research project are to identify which species are present in the Mariarano and Matsedroy forests, to characterize spatial patterns and temporal trends in biodiversity, to monitor the condition of the forest habitat, to provide sustainable revenue to local villages and leverage further funding for environmental projects from the research results. Additionally, we aim to assimilate data from the biodiversity surveys in Mahamavo into global datasets and indicators including the Living Planet Index (LPI) and the Global Biodiversity Information Facility (GBIF).

We believe that it is particularly important to undertake long-term biodiversity surveys in Mahamavo because this watershed is a large dynamic landscape which is experiencing changes in land cover and configuration. Climate change is also a potential threat to the persistence of biodiversity features in Mahamavo. Biogeographically, the Mahamavo region is a transition are between Northern and Western species pools, which means that potentially very large numbers of species may be found here, and there is great potential to document range extensions. The region does not contain any protected areas and has received relatively little scientific study.

Methodology

The Mahamavo watershed lies between the larger Betsiboka and Sofia rivers. Within this large area, we have focused our research in Mariarano village. We have established a spatial sampling framework based around nine forest sample routes, each approximately 4km long, which are stratified with respect to forest condition and configuration. For some sampling activities the routes are sample units, whereas for others, the routes are paths used to access around 150 sample sites. Additionally, wetlands are sampled by boat along 6 standard routes and opportunistic observations of animals and plants are collected throughout the wider landscape.

In order to draw valid inferences about trends in relative abundances, all sample units are sampled on repeated occasions by each survey method during a field season. In the field, spatially-referenced observations are recorded on paper data sheets, which are then entered into a custom database. This permits the field data to be queried in multiple ways and combined with ancillary spatial data for further analysis.

Forest structural properties are measured in 150 plots each 20m by 20m. At each plot the circumference and height of all trees with diameter greater than 5cm are measured. Flowering plants are also sampled in plots. In plots, as many species as possible are identified and recorded together with co-ordinates.

Reptiles and amphibians are sampled by walking sample routes on multiple occasions by day and night, as well as by opportunistic searches. When a reptile or amphibian is found, it is identified and recorded with its location. Crocodiles are surveyed opportunistically and by boat along 6 wetland sample routes.

Forest birds are surveyed using 10 minute early point counts in 150 sample sites on at least 3 occasions per year. When a cluster of birds is detected, the species, group size, distance to birds, method of observation (seen, heard) and site co-ordinates are recorded. Additionally terrestrial birds are recorded opportunistically. Wetland birds are also surveyed by boat along 6 wetland sample routes.

Mammals are sampled by walking sample routes on multiple occasions by day and night, as well as by opportunistic searches. When a mammal is found, it is identified and recorded with its location. Mammals are also recorded opportunistically, by boat surveys and by mist netting bats and pitfall trapping small mammals.

Undergraduate Research projects in Mahamavo in 2013

Reptile colour change
Bethany Curtis, University of Southampton
Adam Mason, Northumbria University

This project is focused upon quantifying the colours and colour change abilities of the leaf-tailed geckos *Uroplatus ebenaui, Uroplatus henkeli and Uroplatus guntheri* and species of Day gecko, genus *Phelsuma*. Day geckos are usually very brightly coloured and can exhibit very rapid colour changes in relation to temperature and the presence of predators, *Uroplatus* geckos appear to use colour change for background matching. In this project, a new method involving digital photography will be used to accurately quantify the colours of these reptile species and their substrates to test hypotheses concerning the circumstances in which colour changes occur.

Behavioural ecology of Coquerel's sifaka
Helen Ruffhead, University of Southampton
Sahmorie Cameron, University College London
Rachael Field, Bangor University
Cat McLaren,
Adam MacKinnon, University of Oxford

There are semi-habituated groups of Coquerel's sifaka *Propithecus coquereli* in the Mahamavo forest which can be readily observed. This species is active during the day and lives in small family groups. They appear to favour large fruiting trees. In this project, behavioural observations on multiple occasions will be used to test hypotheses concerning habitat selection and allocation of time budgets to activities such as feeding or vigilance at different times of day and in different habitat contingencies such as canopy height and distance from the forest edge.

Niche partitioning in hameleons, Day geckos and Skinks.
Philip Cassidy, Queen's University
Jack Medley, Glamorgan University
Devin Tucker, University of California Santa Cruz
Isabelle Spall, Glamorgan University
Hannah Worker, University of Sussex

The Mahamavo dry forests support a diverse reptile assemblage. Competitive exclusion theory suggests that sympatric species must partition their niches in some way to persist. In Mahamavo there are two chameleon and skink species and seven species of Day gecko. It is thought that these species may be selecting different microhabitat niches in terms of habitat type, height above ground selected for feeding, branch thickness or substrate temperature. This project will test for competitive interaction and identify how niches are partitioned between these species.

Population ecology of crocodiles
Nicolas Slatton, Queen's Univeristy

In Madagascar the Nile crocodile *Crocodylus niloticus* have strongholds in isolated areas of the west coast including the Mahamavo wetlands. However crocodiles are threatened by egg collection for crocodile farms and by local people killing large crocodiles perceived to be a threat. For these reasons, crocodiles are currently listed on CITES Appendix II in Madagascar and international trade in crocodile products from Madagascar is banned. Since there is very little information about the crocodile population in Mahamavo, this project will undertake a baseline boat survey and estimate population size.

Landscape ecology of reptiles
Alex Sharp, University of Nottingham

The Mahamavo landscape is a complex mosaic of patches which differ in their size, configuration and recent disturbance history. In this project, data on the relative abundance of all reptile species in landscape units will be joined with satellite derived data on the same units to investigate how reptile species respond to landscape configuration. In particular the goal is to identify if any reptile species are area sensitive, edge sensitive or isolation sensitive, and if so to test for any association between species characteristics such as mean body mass and dispersal capabilities. This research will potentially help predict species responses to future environmental change, especially land cover change.

Community ecology of reptiles
Fernando Pardo Urratia, University of St. Andrews

Mahamavo supports a very large assemblage of reptiles. In any given location the assembled reptile community will have been shaped by the abiotic characteristics of the habitat, by the configuration of the landscape affecting how species may move, and by interactions between species. This research project will use a high quality time-series dataset to evaluate the relative important of habitat, landscape and biological factors in structuring both the entire reptile community and also individual guilds.

Species distribution models under climate change for lemurs
Kate Siredzuk, University of Manchester

Species distribution modeling is a technique for linking spatially referenced records of species occurrence – for example collected during appropriately designed field-based biodiversity monitoring programmes – with maps of environmental variables such as elevation, climate, vegetation or human disturbance, in order to create a statistical model of the relationship between a species and its environment, i.e. the species realised ecological niche. GIS can then be used to express the results of models as habitat suitability maps across a desired spatial extent. In this project, distribution models will be built and validated for all lemur species observed in the Mahamavo dry forest under a number of climate change scenarios for Mahamavo and the Boeny region.

Occupancy models for carnivores using camera traps
Arabella Fox, University of Hull

In the Mahamavo dry forest there have been a small number of sightings of carnivores including the Fossa (*Cryptoprocta ferox) and* Falanouc (*Eupleres goudotti),* but not enough observations to infer their distributions or population sizes. The dry forests are also home to relatively large numbers of bush pigs (*Potamochoreus larvatus)*, feeding signs and droppings are often found, but the pigs are shy and very rarely encountered. We also have anecdotal evidence that there are feral domestic cats (*Felis catus)* in the forest, however since their density is unknown it is hard to evaluate if their presence is a significant threat to native biodiversity. For cryptic species such as these, we have deployed a network of camera traps to gain reliable data on distributions, densities and trends through time, without needing to trap animals.

Ecology and behaviour of nocturnal lemurs in the dry deciduous forests of northwestern Madagascar
Emily Cooper, University of Birmingham

Extant Malagasy lemurs have very diverse ecological requirements (microhabitats, sleeping sites etc.), activity patterns (nocturnal, diurnal, cathemeral), feeding habits (folivores, frugivores, omnivores), body sizes (40g - 9.5kg) and social grouping patterns, and the interactions between these parameters, local abundance and spatial distribution of lemur populations in fragments is still largely underexplored. A total of six nocturnal lemur species are known from the Mariarano area, (*Microcebus murinus*, *M.*

ravelobensis, Cheirogaleus medius, Phaner pallescens, Lepilemur edwardsi, Avahi occidentalis). Nocturnal lemurs are generally much less studied than their diurnal cousins but face the same anthropogenic threats. The aim of this study is to explore the ecology, abundance, spatial distribution and behaviour of two different nocturnal lemur species (*Microcebus spp.*). Mouse lemurs (*Microcebus spp*.) live in a dispersed neighbourhood system with animals forming sleeping groups during day and foraging solitarily at night (*Radespiel 2000*). Data on the spatial distribution of nocturnal lemurs species was collected by means of nocturnal survey walks complemented with capture-mark-release sessions in the case of mouse lemurs (*Microcebus spp*.), since the two sympatric congener species cannot be easily distinguished during nocturnal surveys. Data are simultaneously collected on the used microhabitats (e.g. substrate use, height above ground), group size, and behaviour (e.g. locomotion, feeding, flight response, and vocalization) that allow the testing of specific hypotheses.

Species distribution modelling and ecology of vegetation
Paviter Dhillon, University of Staffordshire
Mike Chatting, University of Plymouth
Samuel Grundy, University of Manchester

There is a critical need to develop and validate methods which could make use of the wide range of free satellite data available with global coverage, especially MODIS and Landsat, to improve the estimation and monitoring of above ground biomass, particularly vegetation. Mahamavo offers an excellent case study site to address these issues since it is possible to access both tropical dry forest and savanna systems and because the environment has gradients of disturbance and degradation and is very dynamic such that validation sites which experience a wide range of historical land cover change trajectories can be found.

Monitoring bat populations in Madagascar using bat detectors and automatic analysis of sonograms
Bethany Rutterford, Glamorgan University

The dry forests in Mahamavo support a wide range of microchiropteran bats which use echolocation. These species can be monitored by walking sample routes and along the edges of the forest and wetlands at dusk with a time-expansion bat detector connected to a digital sound recorder and GPS. The sound recording can then be viewed as a sonogram and automatically compared with recordings of known species to identify how many individuals of each species were present on a sampling occasion and their location.

Preliminary Results

Camera Trapping

Camera traps provided further sightings of Falanouc (*Eupleres goudotii*) and the introduced Indian Civet (*Viverricula indica).* Observations of tracks and faeces confirmed the continued presence of Fossa (*Cryptoprocta ferox)* in Mahamavo, although no direct sighting occurred. Multiple observations of feral dogs and cats were also recorded as well as bush pig and zebu.

Avifauna

Wetlands	**Forest**	*Falco newtoni*
Acrocephalus newtoni	*Accipiter francesii*	*Falculea palliata*
Alcedo vintsioides	*Accipiter henstii*	*Foudia madagascariensis*
Anhinga rufa	*Acridotheres tristis*	*Gallinula chloropus*
Ardea cinerea	*Agapornis canus*	*Hypsipetes madagascariensis*
Ardea humbloti	*Alcedo vintsioides*	*Leptopterus chabert*
Ardea purpurea	*Apus barbatus*	*Nectarinia notata*
Ardeola ralloides	*Artamella viridis*	*Nectarinia souimanga*
Bubulcus ibis	*Buteo brachypterus*	*Neomixis tenella*
Butorides striatus	*Centropus toulou*	*Nesillas typical*
Charadrius marginatus	*Cisticola cherina*	*Newtonia brunneicauda*
Dendrocygna viduata	*Copsychus albospecularis*	*Oena capensis*
Dryolimnas cuvieri	*Coracina cinerea*	*Phyllastrephus madagascariensis*
Egretta alba	*Coracopsis nigra*	*Ploceus sakalava*
Egretta dimorpha	*Coracopsis vasa*	*Polyboroides radiatus*
Gallinula chloropus	*Corvus albus*	*Rostratula benghalensis*
Haliaeetus vociferoides	*Coua coquereli*	*Tachybaptus pelzelnii*
Milvus aegyptius	*Coua cristata*	*Ploceus sakalava*
Numenius phaeopus	*Coua ruficeps*	*Terpsiphone mutata*
Nycticorax nycticorax	*Cuculus rochii*	*Treron australis*
Phalacrocorax africanus	*Cyanolanius madagascarinus*	*Turnix nigricollis*
Platalea alba	*Cypsiurus parvus*	*Upupa marginata*
Porphyrio porphyrio	*Dicrurus forficatus*	*Vanga curvirostris*
Terpsiphone mutata		

Herpetofauna

Herpetological Research and Specimen Export at Mahamavo 2013

Specimen Collection

Whole reptile specimens taken as voucher specimens were euthanized with 96% EtOH and stored in 70% EtOH in accordance with guidelines for humane specimen collection in the field.

Tissue samples were taken in accordance with standard guidelines for sample collection and are stored in 70% EtOH.

We have taken voucher samples of animals that we deem to be of taxonomic (potentially new species) or conservation importance e.g. *Uroplatus spp*. The collection of these specimens will allow us to conduct taxonomic and phylogenetic analysis to determine if the specimens are in fact new to science or a substantial range extension for an animal considered to be restricted in range with little natural history information available. The reason for collection of tissue samples from known species is twofold; they will allow us to monitor the effect of habitat alteration and degradation on the genetic composition and demography of animals of conservation importance and they will allow us to conduct phylogenetic analysis on species that are known to be a complex of species with undefined phylogenetic relationships. The analysis of the voucher specimens will also assist in helping to conserve the Mahamavo dry forest ecosystem especially if some, if not all, of them turn out to be endemic to the area.

The collection of these specimens will also produce a reference collection for the area that could be of use to future studies.

Herpetology Student projects in Mahamavo 2013

Bethany Curtis, University of Southampton – Colour and substrate matching in *Uroplatus* geckos
This project is testing the hypothesis that *Uroplatus ebenaui* and *Uroplatus guentheri* differ in their favoured substrate (such as bark, leaf litter, bare soil) and differ in the degree to which they can match their colouration to a given substrate. Photographs have been taken of geckos on substrates, including in the photograph standard black and white plates painted with Krylon paint. This permits calibrated reflectance of geckos and substrates to be retrieved from photos.

Adam Mason, Northumbria University – Diurnal variation in colour in *Phelsuma* geckos
Phelsuma geckos are able to change their colouration to match their substrate. This project will use similar photographic methods as described above to test whether the ability to background match (dissimilarity between colour of lizard and substrate) depends of time of day. This may occur because lizards must meet conflicting requirements for thermoregulation, camouflage and huntig insect prey against a changing light environment during the diurnal cycle.

Devlin Tucker, University of California Santa Cruz – Niches selection by *Phelsuma* geckos
In the Mahamavo forest there are several sympatric species of geckos, *Phelsuma kochi, P. abbotti, P. lineata, P. laticauda*. This project is exploring microhabitat niche selection by measuring properties of the locations where geckos are observed such as ambient temperature, height above ground and perch diameter. Randomisation tests have then been used to test whether niches differ significantly between the species.

Hannah Worker, University of Sussex – Niche selection by *Trachylepis* skinks
Trachylepis elegans and *Trachylepis gravenhorstii* skinks occur together in the Mahamavo forest. This project is exploring how these species can co-exist by measuring microhabitat properties in skink locations and using randomisation methods to test for niche overlap and niche selection.

Isabelle Spall, Glamorgan University – Niche selection by *Phelsuma* geckos
In this project, the student is testing whether several species of *Phelsuma* geckos differ significantly in their selected microhabitat niches. This requires measurement of microhabitat properties of both lizard locations and randomly chosen null locations followed by randomisation methods implemented in the R package adehabitat.

Fernando Pardo Urrutia, University of St Andrews – Species distribution models for reptiles
Over four years of surveying reptiles in the Mahamavo forest, we have collected large numbers of unique spatial records of more than 55 species of reptile. In this project, these records will be used together with maps of environmental variables such as vegetation greenness and topographic slope to build and validate distribution models for each species using Maxent. The results for each species will then be combined to explore various aspects of the reptile assemblage including identification of hotspots of alpha and beta diversity, clustering reptile species into communities and relating these to environmental gradients, and conservation planning to identify areas of the greatest relative irreplacability.

Phillip Cassidy, Queens University – Population ecology of chameleons
In the Mahamavo forest, reptiles are surveyed by walking standard routes on multiple occasions. Whenever a reptile is encountered it is identified to species level and the location is recorded with a GPS receiver and the perpendicular distance from the route to the animal is estimated. This dataset, extending over 4 years, permits the density *of Furcifer angeli and Furcifer oustaleti* to be estimated using distance sampling and the occupancy dynamics of route segments can be characterised using

occupancy models. Together with ancillary information about habitat properties at moderate resolution, these methods allow the processes structuring the competitive interactions between the two chameleon species to be understood.

Jack Medley, Glamorgan University – Niche selection by chameleons

There are two sympatric chameleon species in Mahamavo; *Furcifer angeli* and *F. oustaleti*. This student is surveying for chameleons and each time that either species is encountered, some aspects of the microhabitat of the chameleon are recorded such as height above ground and perch diameter. This data will then be used to test whether selected microhabitat niches differ significantly between the species.

Herpetofauna Species List

The current number of species for reptiles and amphibians is 59 (50 reptiles, 9 amphibians) as of August 2013

Acrantophis madagascariensis	Madagascarophis colubrinus
Boophis doulioti	Madascincus intermedia
Crocodylus niloticus	Mantidactylus ulcerosus
Dromicodryas bernieri	Mimophis mahfalensis
Dromicodryas quadrilineatus	Madatyphlops arenarius
Ebenavia inunguis	Bibilava lateralis
Furcifer angeli	Oplurus cuvieri
Furcifer oustaleti	Oplurus cyclurus
Geckolepis maculata	Paracontias sp.
Geckolepis polylepis	Paroedura stumpfii
Geckolepis typica	Paroedura vazimba
Hemidactylus frenatus	Pelomedusa subrufa
Hemidactylus mercatorius	Pelusios castenoides
Heterixalus luteostriatus	Phelsuma abbotti
Heterixalus sp.	Phelsuma borai
Heterixalus tricolor	Phelsuma dubia
Heteroliodon sp	Phelsuma kochi
Hoplobatrachus tigerinus	Phelsuma laticauda
Icthycyphus miniatus	Phelsuma lineata
Laliostoma labrosum	Phelsuma mutabilis
Langaha madagascariensis	Ptychadena mascareniensis
Langaha pseudoalluaudi	Sanzinia madagascariensis volontany
Leioheterodon madagascariensis	Scaphiophryne aff. calcarata A
Leioheterodon modestus	Stenophis pseudogranuliceps
Liophidium torquatum	Stenophis variabilis
Liophidium vaillanti	Trachylepis elegans
Lygodactylus tolampyae	Trachylepis gravenhorstii
Voeltzkowia mira	Uroplatus ebenaui
Zonosaurus laticaudatus	Uroplatus gunteheri
	Uroplatus henkeli

Lemur Species List

Avahi occidentalis
Cheirogaleus medius
Eulemur fulvus
Eulemur mongoz
Lepilemur edwardsi
Microcebus murinus
Microcebus ravelobensis
Phaner pallescens
Propithecus coquereli

Small Carnivores and other Mammal Species

Chaerephon leucogaster
Cryptoprocta ferox
Eliurus myoxinus
Eupleres goudotii major
Microgale brevicaudata
Potamochoreus larvatus
Pteropus rufus
Rattus rattus
Rousettus madagascariensis
Setifer setosus
Suncus madagascariensis
Viverricula indica

Botanical Species

Adino?	Ficus grevei	Pittosporum sp
Albizia mainaea	Filicum decipiens	Plagiosciphus sp
Albizia sp	Garcinia dalleizettei	Polyalthia henricii
Apodytes sp	Grevea sp	Polycardia sp
Artabotrys scitophyllus	Hazunta modesta	Polyscias sp
Bathiorhamnus cryptophorus	Hibiscus dicrersifolia	Psorospermum revolutum
Baudouinia fluggeiformis	Hildegardia erythrosiphon	Pyranthus lucens
Blotia sp	Homalium sp	Rauvolfia sp
Brachylaena perrieri	Hugonia sp	Rothmania sp
Brackenridgea madecassa	Ixora elliotii	Sarcolaena eriophora
Brexia madagascariensis	Lasiodiscus pervellei	Sarogavo ala?
Bridelia pervilleana	Leea guinensis	Schrebera trichoclada
Carissa sessililflora	Leptolaena sp	Stereospermum euphoroides
Carissa sp	Ludwigia parviflora	Strobilanthes sp
Cedrelopsis sp	Macphersonia gracilis	Strobilanthes sp
Chrysophyllum sp	Macphersonia gracilis	Strobilanthes sp
Cinnamosma fragrans	Malleastrum gracile	Strobilanthes sp
Colubrina decipiens	Mammea sp	Strophantus boivini
Dalbergia trichocarpa	Margaritaria sp	Strychnos decussata
Diospyros pervillei	Mojiro?	Strychnos sp
Diospyros pervillei	Monanthotaxis micrantha	Tamarindus indica
Dorathoxylon chouxi	Monanthotaxis sp	Terminalia tetrandra
Dypsis sp	Mundelea sp	Tina chapelieriana
Elaeocarpus subserratus	Mussaenda arcuata	Tricalysia majungansis
Eliea articulata	Norhonia boinensis	Tricalysia ovalifolia
Erythroxylum coffeifolium	Noronhia seyrigii	Trilepisium madagascariense
Erythroxylum eligulatus	Ochna pervilleana	Trilepsium sp
Eugenia sp	Olax dissitiflora	Uapaca sp
Evonymiopsis longipes	Oncostemum botryoides	Uncarina decaryi
	Phyllanthus tenullus	Vepris sp
		Viscum trachycarpum