Bat Conservation Madagascar

Consolidation Award Winner 2005/2006
Final Report to the BP Conservation Programme

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Final Report

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Executive Summary

Madagascar is a priority for biodiversity conservation because of its many endemic species and ongoing habitat degradation. Although bats make an important contribution to biodiversity in the tropics, they were neglected by scientists in Madagascar for many years. Capacity building projects to address this situation were successful in creating a group of skilled Malagasy bat workers but didn't establish an organisation from where this unique team could operate. Accordingly, this BP Consolidation Award's priority task was to create a sustainable Malagasy bat conservation organisation. *Madagasikara Voakajy* was launched in May 2005 as is the leader in bat conservation and now employs a total of 24 people. During 2004/05 our team and co-workers described three new species of endemic bat, set up Madagascar's first bat monitoring programme, launched a bat conservation education initiative for primary schools and surveyed bats in forests and caves across the island. The information collected during our fieldwork has already been used to update the IUCN Red List, as well as raising the conservation profile of bats in many protected areas. The Madagasikara Voakajy team levered over $500,000 of additional funding, a feat only possible because of the sound base that the new institution provided for scientists to raise funds. Madagasikara Voakajy is now approaching its 2nd birthday and projects continue in the east, west and south-east of Madagascar to study, conserve and protect the islands bats through collaborations with Malagasy government, universities, NGOs and local communities. None of this would have been possible without the support from the BP Conservation Programme, the legacy of which is intrinsically linked to Madagasikara Voakajy.

1. INTRODUCTION

1.1 Background

A series of projects, funded by the Darwin Initiative and BP Conservation Programme, designed to train Malagasy students in bat conservation between 1999and 2004 were successful in establishing a core group of experienced national biologists dedicated to conserving the islands frugivorous and insectivorous bats. The BP Conservation Programme project was challenged with the task of consolidating this expertise by creating a Malagasy biodiversity organisation with the capacity to lead the field of bat conservation in the future through being a permanent entity in the environment sector in Madagascar.

1.2 Project Members

Richard Jenkins, as project leader, led the creation of Madagasikara Voakajy and is the Director of the organisation. He is employed by the University of Aberdeen. His main role during the project was general management, fund raising, scientific supervision and liaising with the BP Conservation Programme.

Daudet Andriafidison is a senior member of the Madagasikara Voakajy team and is responsible for conservation projects on the Madagascar flying fox *Pteropus rufus*. He oversaw a range of different projects, including baobabs, conservation education, GIS training and working with grassroots organisations.

Radosoa Andrianaivoarivelo is a senior member of the Madagasikara Voakajy team is responsible for conservation projects on Madagascar's smallest fruit bat *Rousettus madagascariensis*. He supervised a range of projects, including field surveys in Parc National Tsingy de Bemaraha and in the eastern rainforests.

Julie Razafimanahaka completed her diploma during the project through a WWF Prince Bernhard Scholarship. She led research teams to Parc National Ankarafantsika and Tampolo forest and managed the insectivorous bat database.

Amyot Kofoky was responsible for microchiropteran surveys and he specialized on acoustic sampling methods.

Richard, Daudet, Rado and Julie remain with Madagasikara Voakajy but Amyot Kofoky left the project in August 2006. Numerous other colleagues and assistants at Madagasikara Voakajy assisted during the course of the work and they are listed in the acknowledgements.

1.3 Aims & Objectives

This bat conservation project had five main aims:

1. Create a Malagasy bat conservation organisation
2. Undertake species conservation initiatives
3. Raise the capacity of Malagasy students and organisations to conserve bats
4. Improve public awareness about bat conservation
5. Support grassroot bat conservation groups

2. Creating Madagasikara Voakajy

2.1 Objectives	
i)	Lever additional funding
ii)	Register a new organisation with the Malagasy government
iii)	Recruit a board of Malagasy trustees
iv)	Define the mission statement
v)	Develop promotional material
vi)	Recruit essential support staff

2.2 Justification

The absence of qualified bat biologists in Madagascar was the main reason for launching the original capacity building projects. The expertise and enthusiasm that resulted was in danger of being denuded and dissipated by the lack of opportunity for these people to engage in bat conservation. After seeking advice from Malagasy institutions and partners, as well as international NGOs it was decided that creating a new Malagasy organisation was the best way to secure and strengthen the investment in training and capacity building.

2.3 Activities and Progress

We received technical support from Conservation International who provided a consultant who guided the project team through the process of creating the new organisation. This included agreeing on a new name and mission statement. At this stage we made the strategic decision to widen our remit to include other small vertebrates. Malagasy legislation does not currently permit the creation of actual NGOs and we therefore registered as an association but with the structure and ethos of an NGO so that we can easily become an NGO-proper in the future.

2.4 Evidence for success

- Madagasikara Voakajy, a new Malagasy biodiversity organisation was created on 10th May 2005
- Five influential Malagasy conservationists agreed to form our advisory board

  President Nanie Ratsifandrihamanana
  (Director of Conservation, WWF Madagascar)
  Dr Joelisoa Ratsirarson

(General Secretary, Ministry of the Environment, Water & Forests, 2006/07 & Professor, ESSA-Foret, University of Antananarivo)
Dr Daniel Rakotondravony
(Head, Department of Animal Biology, University of Antananarivo)
Dr Jonah Ratsimbazafy
(Scientific Coordinator, Durrell Wildlife Conservation Trust, Madagascar)
Mrs. Chantal Andrianarivo
(Head of Biodiversity & Research, ANGAP)

- Board meetings were held on 29th September 2005 and 6th June 2006
- WWF agreed to support the design of our financial and administrative system as well as recruiting and training our accountant
- The number of Malagasy biologists employed has increased from 5 in early 2005 to 9 at the end of 2006
- During the 2 years of the Consolidation Award, we levered an additional $675,000 for Madagasikara Voakajy projects (Appendix 1)

Additional activities, such as the creation of a website and publicity brochure are underway and are expected to be completed in the second half of 2007.

4.6 Appendix Material

i) Photocopy of Madagasikara Voakajy registration document
ii) List of funding levered by the BP Consolidation Award

3. SPECIES CONSERVATION INITIATIVES

3.1 Objectives Undertake Species Conservation Initiatives	
i)	Assess the foraging and roosting habitat needs of the Madagascar sucker-footed bat *Myzopoda aurita*
ii)	Investigate the ecology of Madagascar's smallest fruit bat species, *Rousettus madagascariensis*
iii)	Survey the cave and forests in Madagascar's karstic regions
iv)	Study the relationship between flying fox pollinators and endangered baobab trees

3.2 Justification

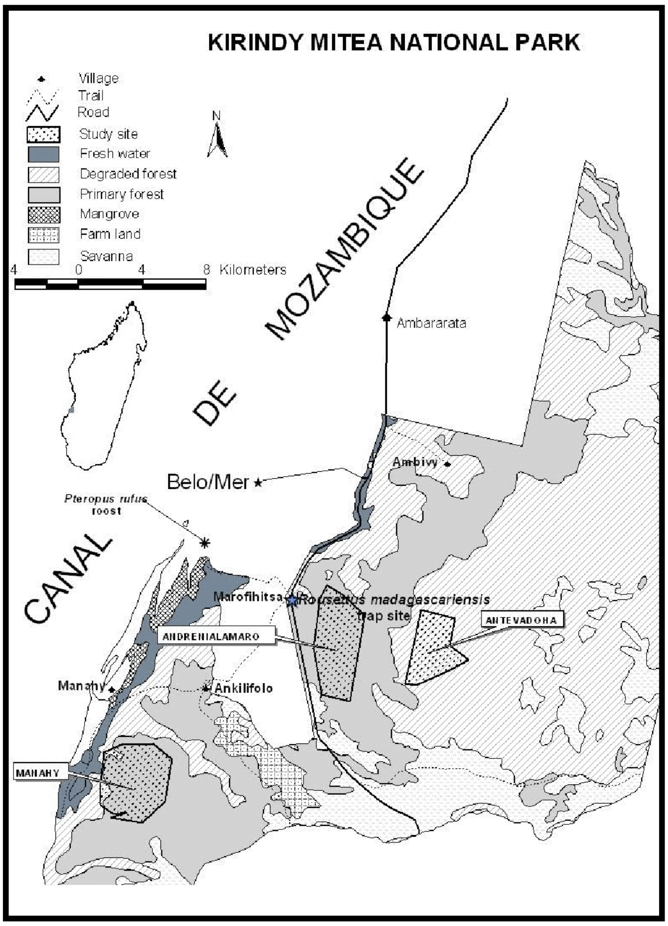
Information on the behaviour, diet, abundance and habitat preferences are prerequisites to accurate conservation assessments. As bats had been neglected for so long in Madagascar there were many gaps in our basic understanding of their natural history, ecology and taxonomy and we identified the need to undertake detailed field studies of key species according to the objectives below:

3.3 Activities & Progress

We have made significant progress in all of the above objectives and, due mainly to the additional funding that we acquired, have significantly expanded our bat species conservation initiatives. Summaries of our main project activities are outlined below:

3.3.1 Flying foxes and baobabs

Our fieldwork in Parc National de Kirindy-Mitea, in June and July 2005, demonstrated that flying foxes are the main pollinators of the IUCN Endangered baobab tree *Adansonia grandidieri.* This study also reported the first observations of the Madagascar Flying Fox *Pteropus rufus* feeding on the nectar of baobab flowers.



Map of Parc National Kirindy-Mitea

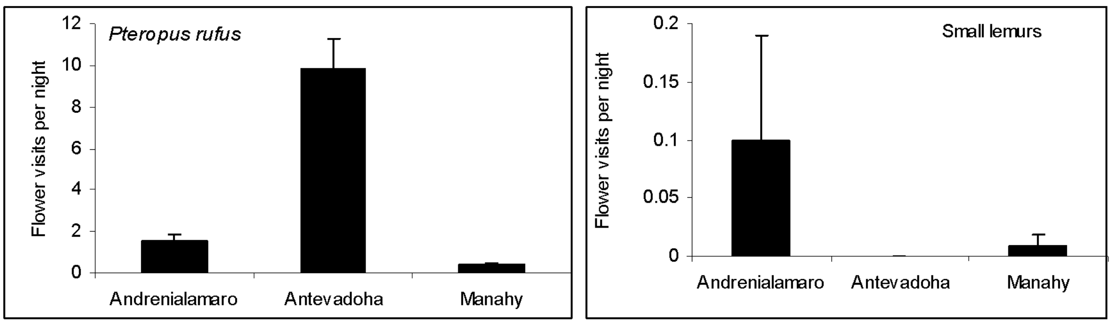
In PN de Kirindy Mitea we studied the baobabs and nocturnal pollinators in three different parts of the park that corresponded to relatively intact forest (Manahy), degraded forest (Andrenialamaro) and deforested land used for agriculture but with standing baobabs (Antevadoha). At each site we used the following methods:

i) Baobab trees were counted along a 500 m transect and perpendicular distances were measured. Each tree was also assessed for damage by local people
ii) Focal baobab trees were selected in the afternoon prior to nocturnal observations and selection was based on the presence of flower buds
iii) The vegetation around each focal tree was quantitatively described and particular attention was paid to the distance from the baobab crown and other canopy vegetation

iv) Two people positioned themselves around a single baobab tree from 16:30 and waited for baobab flowers to open. A small number of new flowers were then selected as focal flowers
v) Using torches and binoculars the number of fruit bat and lemur visitors were counted during each hour throughout the night
vi) Surveys of all known or potential fruit bat roosts were made

Out of the 48 baobab trees that we assessed, six had ladder rungs carved into the bark which were used by local people to facilitate honey collection or setting nets for fruit bats. Fourteen trees had been subjected to bark removal by local people who use the material for house repairs or making rope. In total, 17 of the 48 trees (35%) were damaged by local people. Use of baobab trees by people was greatest in Antevadoha, the most degraded forest, where bark had been removed from 50%, and ladders present in 25% of the 20 focal trees. There was no clear pattern of tree selection by local people; baobab diameter at breast height of trees with removed bark was 6.2 m ± 3.1 SD and from trees without removed bark was 6.2 ± 2.3 SD.

We made observations at 13 trees in Antevadoha, 13 in Manahy and 9 in Andrenialamaro between 19th June and 10th July 2005. We identified *Pteropus rufus* from direct observations on the baobab trees and following mist net captures. *Rousettus madagascariensis* was also trapped in the vicinity and may also feed on baobab flowers.



Nocturnal visits by fruit bat and small lemurs to baobab flowers

Visitation rates of *P. rufus* were highest in the degraded forest of Antevadoha (Figure 1). Small lemurs were not recorded from this site but were observed frequently in Andrenialamaro (Figure 1). Single *Pteropus rufus* usually occupied individual baobab trees and this behaviour was probably related to the availability of nectar; in villages less than 2 km from our study sites we observed over 20 *P. rufus* feeding on individual kapok *Ceiba pentandra* trees, which presumably has more nectar than the baobabs

PN de Kirindy-Mitea is unusual in Madagascar because it has two *Pteropus rufus* roosts within its boundaries; most protected areas have no fruit bat roosts. We made visits to these roosts during August 2004 and June 2005. We provided the ANGAP management team with information on the ecology of *P. rufus* and advised them on how to incorporate the roosts into tourist circuits. These roosts offer the best chance to see roosting *P. rufus* in all of Madagascar's national parks and as the nearby town of Belo-sur-la-mer becomes increasingly popular with tourists there is every chance for ANGAP to include flying foxes in their ecotourism policy. Flying foxes can be legally hunted outside of parks in Madagascar and accessibility of these roosts by pirogues is a cause for concern. We often observed people hunting *P. rufus* as the bats fed on kapok trees in the villages. This type of hunting is likely to be far less damaging than the reports of visits to roosts by people with guns. A study of the impact of hunting and disturbance on the bats is now needed.

In Antsiranana we visited the remaining baobab forests and searched for flying fox roosts. This whole area is currently unprotected but there are a number of plans underway that will lead to the creation of new reserves in the region. We discovered two roosts of *P. rufus* that contained between 10 and 100 bats and a single *E. dupreanum* roost with up to 10 bats. These abundance estimates are rather low, especially compared to the large roosts discovered in PN Kirindy-Mitea. The roosts were located outside of the baobab forests and thus further demonstrate that, for the long term survival of the baobabs, sites with significant numbers of pollinators need to be conserved even when they occur outside of protected area boundaries.

Conclusions

1. Forest degradation reduces the role of lemurs as pollinators of endangered baobabs
2. Flying foxes appear less impacted by forest degradation and can pollinate baobabs even in highly modified habitats (e.g. agriculture)
3. Flying fox roosts are located some distance from the baobab trees and are rarely included in conservation plans

Recommendations

4. The ecotourism potential of the flying fox roosts in Parc National Kirindy-Mitea should be developed
5. Regular patrols should be made of the flying fox roosts in Parc National Kirindy-Mitea to guard against hunting
6. The impact of hunting (at the roost and at feeding sites) and disturbance (hunters at the roost and touristic visits) to bats at Parc National Kirindy-Mitea needs to be investigated
7. Flying fox roosts in the north should be included within new conservation areas proposed for the region

Relevant Outputs

Andriafidison, D., R. A. Andrianaivoarivelo & R. K. B. Jenkins. 2006. Records of tree roosting bats from western Madagascar. African Bat Conservation Newsletter **8**: 5-6.

Andriafidison, D., R. A. Andrianaivoarivelo, R. K. B. Jenkins, O. Ramilijaona, M. Razanahoera, J. MacKinnon & P. A. Racey. 2006. Nectarivory by endemic Malagasy fruit bats in the dry season. Biotropica **38**: 85-90.

3.3.2 *Myzopoda* habitat use

Our survey in Parc National Tsingy de Namoroka collected *Myzopoda* individuals that were recently described as a new species to science. In addition, we also made the first observations of *Myzopoda* roosting in a cave. In the forest of Tampolo we radio tracked *Myzopoda aurita* to *Ravenala madagascariensis* trees, thus confirming the long-held belief that these bats used broad-leafed plants for roosting.

Relevant Outputs

Kofoky, A., D. Andriafidison, J. H. Razafimanahaka, R. L. Rampilimanana & R. K. B. Jenkins. 2006. The first observations of *Myzopoda* sp. (Myzopodidae) roosting in western Madagascar. African Bat Conservation Newsletter **9**:5-6

Goodman, S. M., F. Rakotondraparany & Kofoky. in press. The description of a new species of *Myzopoda* (Myzopodidae: Chiroptera) from western Madagascar. Mammalian Biology **72**:75-81.

3.3.3 Ecology of *Rousettus madagascariensis*

We studied this species in the east and west of Madagascar and provide details in this report on the work in Maromiza forest in the east. *Rousettus madagascariensis* is the smallest Malagasy fruit bat species and is probably the only one of the three that is capable of flying inside closed forest. For this reason, its may have a unique role as a pollinator and seed disperser.

Bats were trapped near to the cave entrance before dawn as they returned to their day roost. Mist nets were erected outside of the roost during the afternoon before each trapping session. Between July 2004 and May 2005 we trapped returning bats on six occasions. Bats were measured (forearm length, mm, and weight, g), sexed, aged and their reproductive status assessed near to the trap site and were typically released 15 minutes after capture and always before sunrise.

Six bats were fitted with collars containing PD-2 radio-transmitters (Holohill Systems Ltd.). Complete units weighed no more than 3 g (*ca.* 4.5 % of the body mass of *R. madagascariensis*) and had an expected life of 12 weeks. Output from the radio transmitters were monitored using Yagi directional antennae fitted to Regal 2000 (Titley Electronics) receivers. Two teams consisting of 2-3 people tracked the bats using Yagi directional antennae on foot or from a vehicle during January, March and April 2005. Fixed reference points were made at a number of locations within the study site and logged on a GPS unit. Bearings were taken on a handheld compass and were read to the nearest degree. Positions of stationary bats were determined by triangulation from either the fixed points or from mobile tracking teams in radio contact. Bearings, time, signal strength and gain were recorded every 15 minutes. We tracked feeding or stationary bats to actual foraging sites where they were observed and location was recorded. Fixes, determined from triangulation or direct observation were transferred onto a large scale (1/100,000) topographic map of the area and plotted in ArcView.

Additional trapping with mist nets was undertaken at feeding sites identified during the radio tracking. Netted bats were fitted with light tags that permitted observation of foraging behavior. Day visits to the cave checked whether bats light-tagged at night were from our study roost.

After determining preferred feeding sites we mist netted in these habitats with increasing distance from the roost.

Plastic sheeting was placed on the cave floor directly under roosting bats for 5 days every two weeks. Faecal matter was removed, sun-dried and stored for later identification. Collections of fruits were made every month throughout the study to create a seed reference library. Faeces were sorted under a low-power microscope and seeds were extracted and identified using the reference collection from the field and those held at herbariums in Antananarivo (GEREM, Tsimbazaza Botanical and Zoological Park and the Department of Botany, University of Antananarivo). The length and width of seeds were measured using a graticule.

A transect crossing four types (humid and *Eucalyptus* forests, agricultural land and scrubby regrowth) of habitat was surveyed for fruit each month near the study area from October 2004 to April 2005. Fruits were collected and identified and their seeds measured and stored for reference.

Germination of seeds extracted from bat faeces were compared to those taken from ripe fruits. Seeds were either collected two weeks or four weeks before the experiment started. Seeds were mixed with anti-fungicide and arranged on moistened filter paper and placed in a 8 x 8 cm covered box for germination (Lieberman et al. 1979). Ten seeds were sowed into each box and six boxes for each treatment were used. All trials were conducted in Antananarivo in partial shade and under room conditions of temperature and day length (i.e. 15–28°C and 12 hours of daylight). Samples were inspected every two days for signs of germination using a hand lens, until several successive inspections revealed no further germination (one month). A seed was considered to have germinated upon the first appearance of the radicle. The effect of ingestion on the speed of germination (i.e. the number of days) was analyzed by calculating the mean number of days from sowing to germination.

A total of 175 *R. madagascariensis* were caught (116 adults and 59 juveniles, 96 females and 79 males) during the study. Most (153) were netted at the cave entrance (423 net hours), but six were trapped in five relatively intact humid forest sites (270 net hours) and 16 in banana plantations (270 net hours).

We trapped more adult female bats than adult males in December and July but fewer in October (Table 1). Pregnancy was observed during October and December. All lactating bats trapped in December and January were carrying their young; births were therefore late November to January. Juvenile bats were trapped during all the study months with the exception of December. The features used to distinguish adults and juveniles were no longer evident in December and it appears therefore that *R. madagascariensis* become mature within a single year. Most juveniles were trapped between March and July and were less common in the early rainy season (Table 1).

Table 1. Population structure	Oct.	Dec.	Jan.	Mar.	May	Jul.
All bats (n)	40	13	53	28	7	18
Juveniles (n)	10	0	21	13	5	5
Adult male (n)	24	3	18	6	1	3
Adult female (n)	6	10	14	9	4	10
Parous females (n)	5	0	9	9	2	10
Nulliparous females (n)	6	0	17	8	4	5
Adult Pregnant (n)	1	3	0	0	0	0
Lactating with young	0	7	5	0	0	0

The weight of adult females differed significantly between trapping sessions and they were heavier in December and January (wet season) when pregnancy and lactation occurred and lowest in March and May (ANOVA, $F_{1,47}$= 11.61, P = 0.0142, $mean_{wet}$ = 70.0 g ± 2.76 SE, $mean_{dry}$ = 59.0 g ± 1.97 SE). Male weight did not vary significantly with season (ANOVA, $F_{1,58}$= 0.07; n.s., $mean_{wet}$ = 69.6 g ± 1.16, $mean_{dry}$ = 70.1 g ± 0.90 SE) but was lowest in May. Adults of both sexes reached minimum body mass during the months of May and July.

Faeces of *R. madagascariensis* contained pollen, fruit fibres, leaves and seeds (Table 2). Seeds of six plants species were found in the faeces but they were only common in the diet during March and April (Table 2). The species of Solanaceae and Rosaceae recorded in the faeces were not found during the fruit transects but the four *Ficus* species were observed in fruiting in relatively intact humid forest. *Rousettus madagascariensis* swallowed seeds less than 2.5 mm in length (Table 2). A single *Dypsis* sp. seed (11 x 14 mm) was collected from under roosting bats in the cave and was likely carried there and deposited by bats returning from foraging.

Table 2 Month			MORACEAE			ROSACEAE	SOLANACEAE
	Fecal samples (n)	*Ficus soroceoides*	*Ficus botryoides*	*Ficus pyrifolia*	*Ficus brachyclada*	*Rubus mollucanus*	Sp. a
Oct.	24	0	0	0	0	1	1
Nov.	33	0	0	0	0	0	0
Dec.	30	0	0	0	0	0	0
Jan.	125	0	0	0	0	0	0
Feb.	186	0	0	3	0	0	0
Mar.	107	1	3	17	1	0	1
Apr.	207	0	0	44	0	0	0
May	164	0	0	0	0	0	0
Seed length (mm)		1.0 ± 0.02 (n=13)	1.4 ± 0.02 (n=3)	1.3 ± 0.03 (n =13)	1.2 ± 0.03 (n =13)	1.43 ± 0.02 (n=4)	2.5 ± 0.04 (n=4)

Forty-nine plant species from 24 families found fruiting during the transect fruit survey. Seventeen species were collected in the degraded habitat and farmland and 30 in the native forest. Even though the introduced species of Myrtaceae and Melastomataceae (*Psidium cattleianum* and *Clidenia hirta*) were abundant in March at the study site they were not found in the faeces (Table 2).

Ficus soroceoides seeds that passed through the gut of *R. madagascariensis* germinated significantly faster than those extracted from the fruits (ANOVA $F_{2,15} = 403$, $p < 0.001$). Gut passage seeds germinated on average 2.7 days ± 0.21days (trial 1) and 2.0 days ± 0.00 SE (trial 2) after sowing whilst reference seeds germinated after 9.0 days ± 0.26 SE. Percentage germination however was similar across the three treatments (bat trial 1 = 93%, bat trial 2 = 100% and reference = 100%).

Table 3 Date	Time	Sex	Distance (km)	Site	Age
23/05/2005	20:10	Female	7.3	Ambavaniaso	Adult
23/05/2005	20:25	Male	7.3	Ambavaniaso	Adult
23/05/2005	20:00	Male	7.3	Ambavaniaso	Adult
24/05/2005	19:22	Male	4.6	Bazar Zoma	Adult
24/05/2005	19:17	Female	4.6	Bazar Zoma	Adult
24/05/2005	19:17	Male	4.6	Bazar Zoma	Adult
24/05/2005	19:40	Male	4.0	Amalonabe	Adult
25/05/2005	18:38	Male	8.1	Avoibe	Juvenile
25/05/2005	18:38	Male	8.1	Avoibe	Adult
25/05/2005	19:40	Female	8.1	Avoibe	Juvenile
25/05/2005	19:50	Female	8.1	Avoibe	Juvenile
28/05/2005	19:15	Female	11.4	Madiorano	Adult
28/05/2005	19:23	Female	11.4	Madiorano	Juvenile
28/05/2005	19:23	Male	11.4	Madiorano	Adult
28/05/2005	19:56	Female	11.4	Madiorano	Juvenile
28/05/2005	20:33	Female	11.4	Madiorano	Adult

Sixteen bats were trapped during foraging on banana flowers at five sites east of the cave roost and were fitted with light tags (Table 3). Checks at the cave the following day after light tag attachment found three bats in the roost from feeding sites 7.3 km, 4.0-4.6 km and 8.1 km from the cave (Table 3).

The maximum straight-line distance covered by an individual bat was 14.2km for RMF#1 and 14.8 km for RMM#2 in a single night. On two occasions for each bat we managed to maintain contact throughout the foraging period, from dusk until approximately 03:30. On 24th and 30th March 2005 RMF#1 made round-trip foraging flights of 23.7 km and 27.16 km respectively. On 26th March and 1st April 2005 RMM#2 made round-trip foraging flights of 17.34 km and 15.92 km.

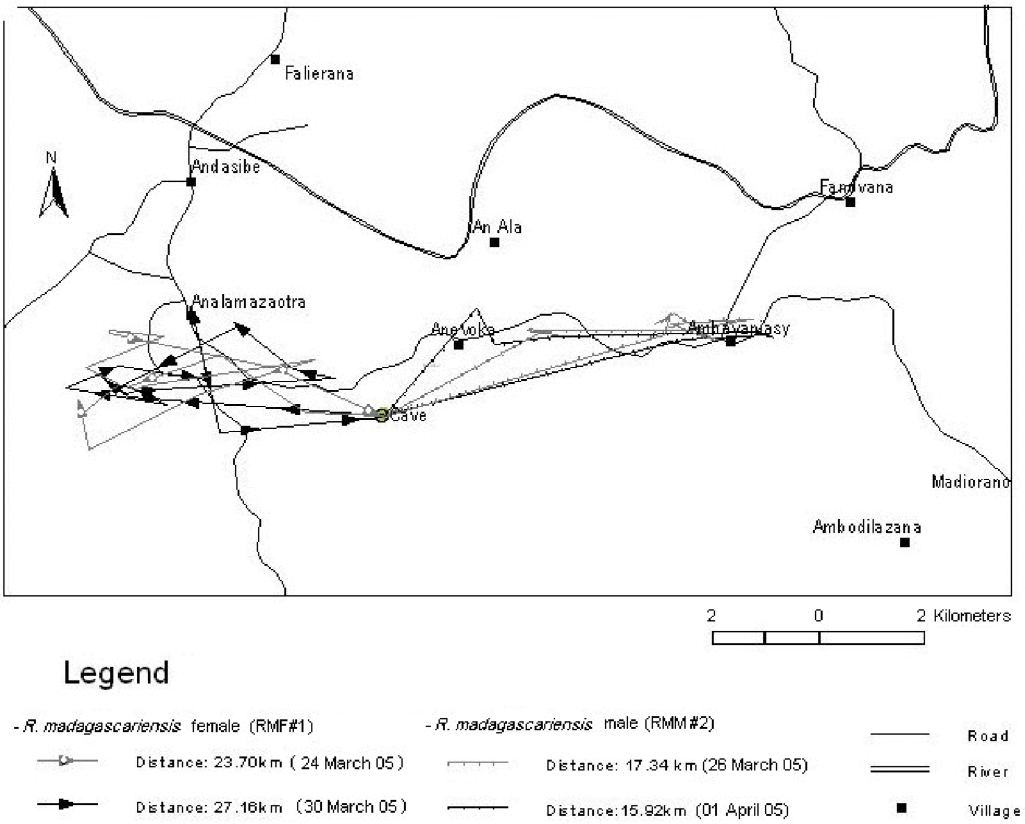


Figure 2. Movements of radio tracked *R. madagascariensis*

Conclusions

1. *Rousettus madagascariensis* feeds on native and introduced plants and the former were most important in between February and April
2. As *R. madagascariensis* is so small, most of the available seeds were too large to be swallowed and seed dispersal is therefore mainly through bats carrying fruit in their mouth
3. Even though *R. madagascariensis* regularly visited villages and fed within metres of houses, local people were oblivious to their presence
4. *Rousettus madagascariensis* travels up to 25 km per night and feeding sites are scattered in the landscape that surrounds roosts.

Relevant Outputs

Andrianaivoarivelo, R. A., O. Ramilijaona & D. Andriafidison. 2007. *Rousettus madagascariensis* Grandidier 1929 feeding on *Dimnocarpus longan* in Madagascar. African Bat Conservation News **11**:3-4.

3.3.4 Bats in karst

We surveyed a number of sites in Madagascar's karst zone which runs along the western flank of the island. The main focus of the work was at Parc National Tsingy de Bemaraha where we surveyed caves and forests. Other sites that we visited included Anjohibe which is a network of caves near Mahajunga. We also participated in a survey that was organised by Birdlife International in the Mahavavy-Kinkony wetland complex.

Bat Habitat Use in Parc National Tsingy de Bemaraha

Mist netting and acoustic sampling were used to assess the activity and composition of the bat fauna in relation to forest edges. The methods varied according to the study site because of the availability of personnel, equipment and local conditions. A general methodology is therefore presented here.

Mist nets were used to trap flying bats between dusk and 22h00. Nets were usually placed in locations deemed to be suitable for trapping bats and these were trails, gaps, rivers and edges. One trap site was conducted each night and usually consisted of 37-42 m of netting. Nets were regularly monitored and the bats were extracted soon after capture. The sampling protocol consisted of trap sites inside the forest, at the forest edge and in non-forest habitats at varying distances away from the forest.

A Pettersson D240x bat detector was used to sample flying bats in time-expansion and the echolocations were recorded directly onto mini-disks. Each point count lasted 5 minutes and was approximately 200-400 m apart. Call sequences were downloaded into a PC and converted to sonograms to identify species. The recordings were analysed with the software BatSoundPro (Pettersson Electronic AB, Uppsala) at a sampling rate of 44.1 kHz, with 16 bits/sample, and a 512 pt FFT with a Hanning window for analysis. Identification of the focal-taxa in this study are straightforward as they have distinctive shapes and frequencies. Additional recordings were made at some point counts simultaneously using broadband methods (heterodyne or frequency division) to sample the activity of the bats as either 'bat passes' or 'feeding buzzes'.

A total of 185 bats from nine species (captures of the fruit bat *Rousettus madagascariensis* are not considered here) were trapped; *Hipposideros commersoni* (n = 58), *Triaenops rufus* (n = 50), *Triaenops furculus* (n = 9), *Miniopterus manavi* (n = 52), *Miniopterus gleni* (n = 1), *Myotis goudoti* (n = 13), *Scotophilus robustus* (n = 1) and *Mops leucostigma* (n = 1).

The furthest trap site was 14 km from the forest and all sites inside the forest are classed as zero metres. There was a significant correlation between distance from the forest and the abundance of all microchiropterans (Spearman Rank Correlation *r* = - 0.55, p = 0.02) and more 30 bats were caught per night in sites up to 2 km from the edge of the protected forest (Figure 2). Species richness of microchiropterans also showed a similar pattern *(*SRC *r* = - 0.49, p = 0.01).

The abundance of *Miniopterus manavi* (SRC *r* = - 0.25, p = 0.02) and *H. commersoni* (SRC *r* = - 0.40, p = 0.02) were also related to forest proximity (Figure 2), but not or *M. goudoti* (SRC *r* = - 0.05, ns) or *T. rufus* (SRC *r* = - 0.20, ns). Two species, *M. goudoti* and *H. commersoni*, were trapped over 10 km from the edge of the protected forest but *M. manavi* was not recorded further than 5 km from the edge (Table 4). Thus, whilst there is a decline in abundance and species richness with increasing distance from the forest, the capture of some species > 10 km from the edge of the national park indicates that either forest habitats are of low importance or that there are forest areas outside of the boundary.

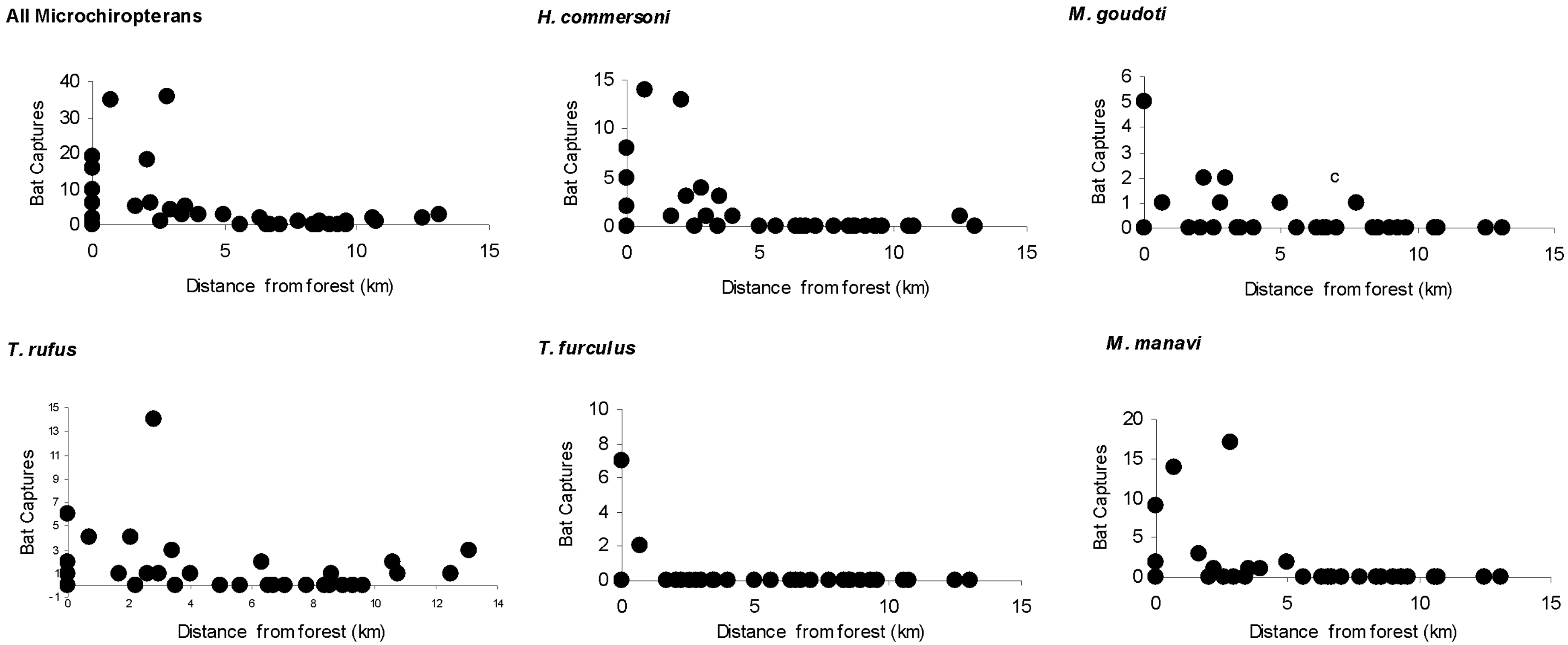

All Microchiropterans
Bat Captures
Distance from forest (km)
H. commersoni
Bat Captures
Distance from forest (km)
M. goudoti
Bat Captures
Distance from forest (km)
T. rufus
Bat Captures
Distance from forest (km)
T. furculus
Bat Captures
Distance from forest (km)
M. manavi
Bat Captures
Distance from forest (km)

Figure 3.

Table 4. The distance between capture site and protected forest for four microchiropteran species		
Species	Mean distance from forest (km)	Maximum distance from forest (km)
H. commersoni	3.3 ± 1.70	12.5
T. rufus	2.9 ±1.95	10.7
M. manavi	2.9 ±1.58	4.9
M. goudoti	0.7 ± 0.40	7.7

Nine microchiropteran species were determined from recordings of echolocations. Seven of these were also netted during the trapping survey, but *Emballonura* sp. and *Miniopterus majori* were only detected acoustically. Of the 303-point count recordings 192 echolocations were attributed to bat species (Table 5) and a further 176 were from unidentified molossid bats. Investigations of habitat use were conducted for species

Table 5. Summary of acoustic sampling results	
Species	Number of acoustic determinations
M. manavi	65
M. majori	43
T. rufus	26
H. commersoni	24
M. goudoti	15
Emballonura sp.	5
M. gleni	5
T. furculus	5
S. robustus	4

Figure 4 gives the proportion of point counts in 16 distance bands, ranging from inside to 13 km away from the protected forest. The only species to display an association with the protected forest were *T. furculus, H. commersoni* and possibly *M. goudoti.* A plot of bat feeding activity against distance revealed two areas of high foraging intensity (Figure), one at the forest edge and the other between 9 and12 km from the boundary of the protected forest. Figure 3 also shows that there was considerable difference between the two sites used and indicates that the forest edge at

Bekopaka was more suitable for foraging bats than at Antsalova. Furthermore, these results reveal low feeding activity inside the forest.

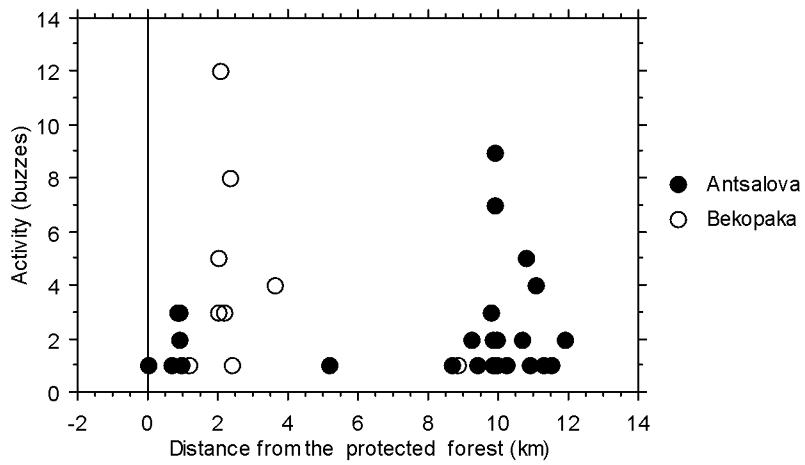


Figure 4. Foraging activity from points counts with acoustic detections at different distances from the edge of the protected forest (= 0 forest edge/park boundary and negative values are forest interior).

Relevant Outputs

Kofoky, A., D. Andriafidison, F. H. Ratrimomanarivo, J. H. Razafimanahaka, D. Rakotondravony, P. A. Racey, and R. K. B. Jenkins. in press. Habitat use, roost selection and conservation of bats in Tsingy de Bemaraha National Park, Madagascar. Biodiversity and Conservation.

Rakotoarivelo, A. & Randrianandrianina, F. (2007). A chiropteran survey of the Lac Kinkony-Mahavavy area in western Madagascar. African Bat Conservation Newsletter **12**: 2-4.

4. TRAINING AND CAPACITY BUILDING

4.1 Objectives	
i)	Sponsor and train Malagasy students to undertake scientific research projects, as part of their post-graduate degrees, on bat conservation science
ii)	Supervise Malagasy PhD students
iii)	Nurture the scientific and managerial skills of Madagasikara Voakajy staff members
iv)	Improve the capacity of protected area staff to identify and conserve bats

4.2 Justification

For Madagasikara Voakajy to achieve its aim of establishing a professional and self-sustaining bat conservation team the individuals concerned must be able to demonstrate excellence in their work. This is important because a high profile and good reputation are essential components of successful fund raising. This capacity building needs to include new trainees, to widen the skills base and prepare for future recruitment. Also, it needs to focus on existing and experienced staff members to help them develop from capable field biologists, of which there are many in Madagascar, to capable conservation scientists and leaders in biodiversity, of which there are relatively few in Madagascar.

4.3 Activities & Progress

Our student training programme works mainly with three different university departments in Madagascar (Département de Biologie Animale, Faculté des Sciences, Université d'Antananarivo; Ecole Superieure des Sciences Agronomiques. Departément des Eaux et Forêts. Université d'Antananarivo; Département de Biologie Faculté des Sciences, Université de Toliara). Students are typically enrolled in MSc-like diplomas on conservation and ecology that last between 2 and 4 years. The diplomas require a field research project and Madagasikara Voakajy works with the institutions' Malagasy scientists to supervise these projects.

Through creating an institution we provide our biologists with the base from which they can obtain new training and learning with other organisations or in the international arena. This project has seen study visits by Madagasikara Voakajy staff and students to the US, Uganda, South Africa, Cameroon and the UK. The institutional support is also important because it provides the Malagasy scientists with the resources needed to publish scientific papers. These outputs are essential components of Madagasikara Voakajy's overall strategy because they make our results available to the general public and demonstrate high quality work.

Examples:

Randrianandriananina, F. ., D. Andriafidison, A. F. Kofoky, R. O. Ramilijaona, Ratrimomanarivo, P. A. Racey & R. K. B. Jenkins. 2006. Habitat use and conservation of bats in rainforest and adjacent human-modified habitats in eastern Madagascar. Acta Chiropterologica **8**: 429-437.

Andrianaivoarivelo, R. A., Ranaivoson, N., Racey, P.A. & Jenkins, R.K.B. 2006. The diet of three synanthropic bats (Chiroptera: Molossidae) from eastern Madagascar. Acta Chiropterologica **8**: 439-444.

Goodman, S. M., F. H. Ratrimomanarivo & Randrianandrianina, F. 2006. A new species of *Scotophilus* (Chiroptera: Vespertilionidae) from western Madagascar. Acta Chiropterologica **27:** 867-882.

Goodman, S. M., Jenkins, R. K. B. & Ratrimomanarivo, F. H. 2005. A review of the genus *Scotophilus* (Chiroptera: Vespertilionidae) on Madagascar, with the description of a new species. Zoosystema **27** 867-882.

Goodman, M., Andriafidison, D., Andrianaivoarivelo, R., Cardiff, S.G., Ifticene, E., Jenkins, R.K.B., Kofoky, A., Mbohoahy, T., Rakotondravony, D., Ranivo, J., Ratrimomanarivo, F., Razafimanahaka, J., Razakarivony, V. & Racey, P.A. (2005). The distribution and conservation of bats in the dry regions of Madagascar. Animal Conservation **8**: 153-165.

The project's chief administrative and financial officer, Mhy Andriamampionona, was recruited with support from WWF who also helped us to implement a new system for contracts and finances. She also attended a week's training course in NGO administration run by MANGO (management of accounting by non-governmental organisations).

During the course of the project two of Madagascar's leading bat biologists, and senior staff within Madagasikara Voakajy, obtained PhD places in the University of Antananarivo. Radosoa Andrianaivoarivelo is studying the conservation ecology of *R. madagascariensis* and Daudet Andriafidison is studying the landscape ecology of *P. rufus.*

Our field teams have held mini-seminars on bat conservation for the teams at each protected area where we visited. At Parc National Tsingy de Bemaraha, this included a 5-day training course during which the 22 guides received formal classroom teaching and accompanied Madagasikara Voakajy biologists into the field to learn how to identify bats. At Parc National de Kirindy-Mitea we provided ANGAP with recommendations on how to responsibly encourage tourism at two large flying fox roosts.

4.4 Evidence for success

- Four trainees are now staff members
    - Noro Razafindrakoto
    - Mahefa Ralisata
    - Andrinajoro Rakotoarivelo
    - Félicien Randrianandrianina
- Five Malagasy students graduated as bat specialists
    - Ralisata, M. (2005). Contribution a l'Etude de Comportement Alimentaire de la Chauve-souris a Nez Feuillu : *Hipposideros commersoni commersoni* (Hill et Bull, 1963) (Chiroptères : Hipposideridae) dans le Parc National Ankarafantsika. Mémoire DEA. Département de Biologie Animale, Faculté des Sciences, Université d'Antananarivo.
    - Mbohoahy, T. (2005). Etude des Eventuelles Relations entre la Morphologie des Microchiroptères, leur lieu de chasse, leurs activités, leurs aliments et les Facteurs Environnementaux. Mémoire DEA, Faculté des Sciences, Université de Toliara.
    - Razafindrakoto, N. (2006). Etude comparative du regime alimentaire de *Pteropus rufus* Tiedemann, 1808 et de *Rousettus madagascariensis* Grandidier, 1928 (Pteropodidae) dans le district de Moramanga. Mémoire DEA. Département de Biologie Animale, Faculté des Sciences, Université d'Antananarivo.
    - Razafimanahaka, H. J. 2006. Etude de l'utilisation de l'espace par *Hipposideros commersoni*, Geoffroy 1813 (Chiroptere : Hipposideridae) dans la foret littorale de Tampolo. Mémoire DEA Ecole Superieure des Sciences Agronomiques. Departément des Eaux et Forêts. Universite d'Antananarivo.
- Four Malagasy students preparing their masters theses
- Two Malagasy biologists undertaking doctoral research on fruit bat ecology
- Eight overseas training visits by Malagasy bat biologists
    - Uganda, Radosoa Andrianaivoarivelo
    - Cameroon, Radosoa Andrianaivoarivelo

  - Uganda, Andrinajoro Rakotoarivelo
  - South Africa, Andrinajoro Rakotoarivelo
  - United Kingdom, Radosoa Andrianaivoarivelo, Julie Razafimanahaka
  - United States, Radosoa Andrianaivoarivelo and Amyot Kofoky
- Ten scientific publications in peer-reviewed journals
- Four scientific publications accepted for publication in 2007
- Four collaborative publications between Madagasikara Voakajy and WWF
- Five Malagasy students completed a Powerpoint course
- Two Malagasy students completed a course on basic computing
- Five Malagasy students completed an accredited GIS course on ArcView
- Eight Malagasy students completed an accredited GPS courses
- Madagasikara Voakajy trained by MANGO and CNaPS (pensions)

4.5 Appendix material

Photocopies of certificates

5. IMPROVE AWARENESS ABOUT BAT CONSERVATION

5.1 Objectives	
i)	Use national media to give bat friendly messages
ii)	Provide parks and reserves with information on bat friendly tourism
iii)	Provide bat education lessons to primary schools

5.1 Justification

As all bats in Madagascar can be legally hunted for food there is very little legislation available to assist conservationists to protected threatened populations. It is therefore essential that in areas that still have large populations, conservation education initiatives are launched to increase the awareness about bats.

5.2 Activities and Progress

We have developed a large conservation education programme for bat education in Madagascar. In April 2005 we held a workshop in eastern Madagascar to discuss ways of incorporating bat conservation into primary school teaching. This was attended by Madagascar-base NGOs (e.g. The Peregrine Fund) with an interest in bat conservation and other NGOs, such as Action Comores, that specialize in bat conservation. We received a bat education kit from Houston Zoo via the American Zoo Association Bat Taxon Advisory Group. The workshop was a great success and identified two strategies for integrating bat education message into primary schools.

The first method is a form of a mobile bat conservation education kit that can be easily transported around the country and to isolated places. This kit consists of bat clothes, masks, models, games and a video in the Malagasy language. School visits usually last two days, the first devoted to teaching the teacher and the second involving the children and usually culminating in a poster drawing competition. Madagasikara Voakajy team has used this kit in many locations across Madagascar, from the south-east to the far-west.

Relevant Outputs

O'Connor, T., P. Riger & R. K. B. Jenkins. 2006. Promoting fruit bat conservation through education in Madagascar. International Zoo Educators Journal **42**:26-33

The second method recommended during the workshop is also now being implemented by Madagasikara Voakajy and it consists of developing formal teaching modules for the curriculum in primary schools. The Madagasikara Voakajy team produced modules for three age groups in primary school and, working closely with the Ministry of Education, are now testing them in three regions of Madagascar (Melaky, Alaotra-Mangoro and Anosy).

Madagasikara Voakajy has also contributed to conservation education in universities. Its team co-authored two modules, one on threatened species and one on bats, for the Réseau des Educateurs et Professionnels de la Conservation a Madagascar, a project organised by the Wildlife Conservation Society.

Some of our work has also featured in the national media. In particular, our flying fox project in the Alaotra-Mangoro has been featured on national television on three occasions and numerous times on radio and in newspapers.

We have provided posters on bat conservation for Association Mitsinjo, near Reserve Specialé d'Analamazaotra and for PN Tsingy de Bemaraha. These are designed to increase awareness about bats amongst local communities, park guide and tourists

5.3 Evidence for success

- Workshop attended by 36 people on bat education organised by Madagasikara Voakajy
- Mobile bat conservation kit developed for schools
- Approximately 17 schools, 1,072 children and 104 teachers have been involved in bat conservation lessons
- Three teaching modules about bat conservation for primary schools currently being tested in 16 schools
- Four bat conservation posters made for partner organisations

6. SUPPORT GRASSROOTS BAT CONSERVATION

6.1 Objectives	
v)	Develop the capacity of our partners e.g. ACCE
vi)	Conduct monthly monitoring at *P. rufus* roosts
vii)	Establish links between communities and bat conservation

6.2 Justification

Collaborations between local and national NGOs are often highly effective because the former has good working relationships and knowledge of local matters and the latter provide technical and financial support. In this project we worked in partnership with Madagasikara Voakajy works closely with Arongampanihy-Culture-Communication-Environment (ACCE) and Mbarakaly, grassroot NGOs based in Moramanga and Anosibe An'Ala respectively.

6.3 Activities and Progress

Our collaboration with ACCE has developed into a major conservation project and is centered around a group of small forest fragments that are used by roosting *P. rufus.* These roosts hold over 4,000 bats but are without protection and are threatened by hunting, bush fires and conversion of forest into rice agriculture.

Relevant Outputs

Jenkins, R.K.B., Andriafidison, D., Razafimanahaka, A. R., Razafindrakoto, N., Andrianadrasana, R. H., Razafimahatratra, E. & Racey, P.A. (in press). Not rare but threatened: the endemic Madagascar flying fox (Pteropodidae): *Pteropus rufus*. Oryx

We have established a monthly monitoring scheme at seven roosts and these visits have also led directly to a reduction in fires at some of the roosts. So that the habitat use of the bats can be better understood we radio tracked 15 bats to identify forest fragments that are important for foraging or roosting bats.

Along with the support of seven mayors we have created *dinas* (community laws designed and enforced by local people) to protect the flying foxes and their roosts. As part of this project, we are rehabilitating or repairing 11 rural primary schools.

We have supported ACCE's team and office and sponsored training courses on GIS, GPS, accountancy and learning English. This additional capacity was put to good use in 2006 when ACC, along with Madagasikara Voakajy and Mbarakaly, surveyed the Zahamena-Ankeniheny corridor for bats. This large area of forest is about to become a new protected area but the boundaries were proposed without reference to the location of bat roosts. We found 46 *P. rufus* roost sites, 16 of which had been destroyed in the last 5 years. The information that we provide to the Malagasy government will be used to improve the conservation status of bat in the region.

Working with Mbarakaly, who also received GIS and GPS training, we have surveyed the district of Anosibe An'Ala and focused our research on the impact that flying foxes have when feeding on litchi crops.

6.4 Evidence for success

- Monthly counts of *P. rufus* submitted regularly to Madagasikara Voakajy
- Improved conservation at seven *P. rufus* roosts in the Alaotra-Mangoro Valley
- Flying fox dina created in seven communes in the Alaotra-Mangoro Valley
- Local politicians support and endorse flying fox conservation
- NGO partners have a higher profile, as evidenced by ACCE's invitation to two international conferences in Antananarivo
- One partner attended am accredited GIS course

Acknowledgements
Richard Jenkins, Daudet Andriafidison, Julie Razafimanahaka and Radosoa Andrianaivoarivelo are grateful to everyone who assisted us obtain the funding from BP and undertake the project. In particular we would like to thank:

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FINANCIAL STATEMENT

Financial Statement
Amount requested = $82,052
Amount received = $70,800
Amount spent = $35,160
Amount reallocated = $35,639

	Budget	**Expenditure**
Madagasikara Voakajy office costs	12,306	3,840
Field work costs	26,863	18,022
Malagasy biologist salaries	26,040	3,546
Vehicle costs (inc. fuel)	5,250	1,017
Consumables	7,044	5,613
Flights (international & domestic)	4,550	3,136
	82,052	35,161

Proposed Budget, Remaining Funds	**2007**	**2008**	**2009**	**2010**	**sub-total**
Madagasikara Voakajy office costs	750	900	900	900	3,450
Field work costs	0	4,000	4,000	4,500	12,500
Malagasy biologist salaries	0	2,000	2,000	2,500	6,500
Vehicle costs (inc. fuel)	0	1,200	1,500	1,500	4,200
Consumables	0	800	800	900	2,500
Flights (international & domestic)	0	2,000	2,000	2,000	6,000
Totals	**750**	**10,900**	**11,200**	**12,300**	**35,150**

ADDITIONAL FUNDING RAISED

Year	Source	Description	
		Total	$683,820
2005	BP Conservation Programme	Travel grant: Julie Razafimanahaka	1,480
2005	BP Conservation Programme	Travel grant: Amyot Kofoky	1,500
2005	Conservation International	Travel grant: Julie Razafimanahaka	750
2005	Conservation International	Travel grant: Amyot Kofoky	1,900
2005	Conservation International	Workshop on flying foxes/education	1,100
2005-06	Conservation International	Assessing forest dependency in microchiropterans	12,866
2005-07	Conservation, Food & Health Foundation	Flying fox conservation in eastern Madagascar	16,160
2005-07	Darwin Initiative	Creating Madagasikara Voakajy	125,650
2005-08	Darwin Initiative	Vertebrate conservation in tsingy	281,925
2005	Fauna & Flora International	Flying fox conservation in eastern Madagascar	8,750
2005	Fauna & Flora International	Bat conservation survey in Anosy Region	1,365
2000-07	Lubee Bat Conservancy	Flying fox conservation (monitoring)	6,185
2005-07	National Geographic Society	Radio tracking flying foxes	22,046
200-06	Rufford Foundation	Microchiropteran conservation	8,736
2005-07	Seacology	Flying fox conservation	30,000
2005	University of Aberdeen	Microchiropteran conservation	875
2005-06	Whitley Fund for Nature	Flying fox conservation	17,500
2005-06	WWF	Prince Bernhard Scholarship: Julie Razafimanahaka	6,048
2006-07	Disney Wildlife Conservation Fund	Fruit bats and people: conservation conflict	17,800
2006-07	Conservation International	Zahamena fruit bat survey	31,500
2007-08	AZA CEF	Fruit bats and baobabs	19,830
2007	British Ecological Society	Hipposideros commersoni	12,250
2007	Wildlife Conservation Society	Hipposideros commersoni	16,000
2006	Fauna & Flora International	Anosy herpetofauna review	3,999
2006	Fauna & Flora International	Flying fox conservation in Anosy	17,605
2007	Lubee Bat Conservancy/Houston Zoo	Flying fox monitoring	2,000
2007-08	People's Trust for Endangered Species	Flying foxes in Menabe	7,000
2007	International Foundation for Science	Fruit bat predation of litchis	11,000