Frontier Madagascar Environmental Research Series

REPORT 14

Montagne des Français
Biodiversity and conservation Evaluation

Frontier Madagascar
2007

Frontier Madagascar Environmental Research

Report 14

Montange des Fançais
Biodiversity survey and conservation evaluation

Green K, D'Cruze N, Robinson J, & Fanning E (eds)

ANGAP

Association National pour la Gestion des Aires Protegees

The Society for Environmental Exploration

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Frontier-Madagascar

Madagascar, the fourth largest islands in the world, is renowned for its high biological and ecological diversity, and is characterised by its high abundance of endemic species. Madagascar is one of the poorest nations in the world and very dependant on the resources the natural environment provides. As a result, conservation and development work is of paramount importance as efforts are made to preserve an environment under pressure from non-sustainable exploitation. Frontier Madagascar is in the process of carrying out baseline survey work in the northern tip of coastal Madagascar, the Antsiranana region, in an effort to provide biological and resource utilisation data for the preparation of sustainable management initiatives for the region.

Institut Halieutique et des Sciences Marines

The Institute Halieautique et des Sciences Marines (IHSM) is part of the University of Toliara in Madagascar. IHSM is a university centre of learning in the field of marine sciences and runs courses for both undergraduate and post graduate students, along with providing consultations to government institutions, NGO's and individuals.

The Society for Environmental Exploration (SEE)

The Society is a non-profit making company limited by guarantee and was formed in 1989. The Society's objectives are to advance field research into environmental issues and implement practical projects contributing to the conservation of natural resources. Projects organised by The Society are joint initiatives developed in collaboration with national research agencies in co-operating countries.

Frontier Madagascar Coastal Research Programme (FMCRP)

The SEE and the IHSM have been conducting collaborative research into environmental issues since 2000 under the Frontier Madagascar banner, FMCRP. Frontier Madagascar conducts research into biological diversity and the resource utilisation of both marine and coastal terrestrial environments. Since moving to Diego Suarez in April 2004 the FMCRP has begun working in collaboration with the University of Antsiranana as well as the IHSM.

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Contents

Executive Summary

This work records the findings of a faunal biodiversity survey conducted in Montagne des Français between April 2005 and June 2006. Surveying comprised of pitfall traps, small mammal traps, MacKinnon's list avifaunal surveying, mist net and hand net capture of bats, herpetological searches, nocturnal searches, casual observations and socio-economic surveys.

The mammals observed include eight species of bat (two megachiroptera), one carnivore (*Galidea elegans dambrensis*), seven small mammals, bush pig, *Potamochoerus larvatus*, and four species of lemur. Of the seven small mammals identified, three are introduced species, and two are unidentified (*Microgale sp*. and *Eliurus sp.*). Only two individuals of *Eliurus sp.* were captured and it is possible that this species is an undescribed species. Further capture of this species is necessary for identification. All four lemur species observed during the study (*Daubentonia madagascariensis, Eulemur coronatus, Lepilemur septentrionalis,* and *Microcebus tavatra*) are endemic to Madagascar and three are listed on the IUCN Red List of Threatened Species. Socio-economic interviews revealed the possibility of another species of lemur existing in the massif (*Hapalemur griseus occidentalis*). Interviews also revealed the possibility of the fanaloka (*Fossa fossana*), fosa (*Cryptoprocta ferox*), and small Indian civet (*Viverricula indica*) existing in the massif. These are all cryptic nocturnal species which could explain the lack of observation. Further surveying focusing on these species is required to confirm their existence in Montagne des Français.

A total of 63 species of bird were observed in Montagne des Français, with an additional 10 species occurring in the mangrove forest at the mouth of the River Betahitra. Of the species observed within the massif 38% are endemic to Madagascar, the Madagascar Crested ibis (*Lophotibis cristata*) is listed as Near Threatened on the IUCN Red List, and three species are listed on CITES Appendix I. Species of low abundance and found mainly in semi-disturbed forest are under great pressure from habitat loss. This includes Madagascar lesser cuckoo (*Cuculus rochii*), peregrine falcon (*Falco peregrinus*), Madagascar starling (*Hartlaubius auratus*), Madagascar pygmy kingfisher (*Ispidina madagascariensis*), Madagascar crested ibis (*Lophotibis cristata*), western scops owl (*Otus madagascariensis*), and hook-billed vanga (*Vanga curvirostris*).

Of the nine amphibians and 52 reptiles observed in Montagne des Français, 96.7% are endemic to Madagascar, with only *Ptychadena mascareniensis* and *Leioheterodon madagascariensis* occuring on other Indian Ocean Islands. In addition, eight species are likely to be endemic to Montagne des Français; *Amphiglossus* sp. nov., *Brookesia* sp. nov., *Heteroliodon fohy*, *Liophidium* sp., *Liopholidophis martae*, *Madagascarophis* sp. nov., *Paroedura* cf. *homalorhina*, and *Paroedura lohatsara*. Species listed on the IUCN Red List include: *Acrantophis madagascariensis* and *Sanzinia madagascariensis volontany* which are listed as Vulnerable, and *Mantella Viridis* which is listed as Critically Endangered.

Socio-economic interviews confirm that the main anthropogenic pressures on the massif are charcoal burning and agriculture practices. These activities are causing vast loss of the native forests which inevitably has a drastic effect on the diverse flora and fauna. Given the high levels of endemic fauna and the current rate of habitat loss through anthropogenic activities, there is a great need for rapid protection of the flora and fauna of Montagne des Français. This will require effective management and monitoring of habitat loss, anthropogenic activities, number of residents within the massif, and the status and extent of the flora and fauna.

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Introduction

Frontier

Frontier is the banner name for the Society of Environmental Exploration. This society was established in 1989 as a non-profit conservation, non-governmental organisation (NGO), dedicated to safeguarding biodiversity and ecosystem integrity. This is achieved through biodiversity assessments and surveys, surveying specific species and their habitats, working with communities and stakeholders to ensure the protection of ecosystems, and through the training of international volunteers and locals in the field of conservation. Frontier projects advance field research and implement projects that will help conserve biodiversity and help develop sustainable livelihoods.

Frontier-Madagascar is a collaboration between Institute Halieutique des Sciences Marine (IHSM) and the Society for Environmental Exploration. Its work in Madagascar began in 1999 with a marine project in Ankao. The terrestrial project began in the Southern Mikea in 2001 and moved to Antsiranana (Diego Suarez) in 2005 where it began work in association with the University of Antsiranana and SAGE (Service d'Appui á la Gestion de l'Environment). The aim of the project in Antsiranana was to assess the biodiversity of Montagne des Français to aid with decision making concerning the mountain's potential to become a protected area.

Montagne des Français

The limestone massif of Montagne des Français is located in the far north of Madagascar, 8km south-east of Antsiranana (Diego Suárez). This is the mostly northerly area of the Western Domain, which stretches from Antsiranana in the north to Mandrare in the south. This area is separated from the rest of the Western Domain by the Sambirano Region. The climate of the region varies around two seasons, the austral winter (April-October) and the austral summer (November-March). During the austral winter the average rainfall is less than 10mm (IUCN/UNEP/WWF, 1987). In the austral summer the Inter Tropical Convergence Zone (ITCZ) moves south reaching northern Madagascar and provokes weak north-westerly winds. During these months 87% of the annual rainfall occurs and there is a high risk of cyclones due to deflection by the larger nearby massifs of Tsaratanana and Montagne d'Ambre. The narrow annual temperature variation (3.2°C) is characteristic of sub-equatorial regions.

Montagne des Français is a limestone massif supporting dry deciduous forest. Due to the proximity of the massif to Antsiranana (Diego Suárez), a highly populated administrative centre, and the presence of a number of settlements on the massif, the flora and fauna are under extreme pressure from anthropogenic activity and little primary native forest remains. Large areas of forest have been cleared for the cultivation of rice and maize, zebu grazing, and the production of charcoal.

The Frontier-Madagascar terrestrial project base camp was situated on the north-eastern side of Montagne des Français, in the Andavakoera region. The village of Andavakoera is approximately 2km from base camp, which was located at the entrance to a canyon that runs through the mountain to the western side (12°19.991'S, 049°21.178'E). As this area is one of the most accessible areas from Antsiranana much degradation of the forests has occurred. The project was situated at this site from April 2005 to June 2006 with short-term camps conducted in surrounding areas.

Introduction

To assess the biodiversity of Montagne des Français several methodologies were employed. All methodologies used by the Frontier-Madagascar terrestrial project have been carefully developed to record data in a reliable and systematic manner to make the data more accessible to the scientific community. These methods were determined following literature searches of similar work and trials in the field were conducted.

The main methodologies employed were aimed at sampling mammals, birds, bats, reptiles, and amphibians. This includes standard trap-site, involving pitfall traps and small mammal traps. Herpetological searches, both diurnal and nocturnal, and casual collections complimented data gathered from trap-sites. MacKinnon's lists technique and casual observations were conducted to survey the bird species. Hand-nets and mist nets were used to capture and identify bat species. To compliment this work socio-economic surveying was conducted with residents of the massif.

Trap-sites

(D'Cruze et al., 2007)

The use of a combination of methods for collecting a range of animal groups in a certain area is called a trap-site. It consists of the application of pitfall and small mammal over a ten day period, and provides a rapid assessment of the species composition of the area. A total of 12 trap-sites and 36 trap-lines were conducted within Montagne des Français (Table 1).

Table 1. Spatial and temporal details of the trap-sites conducted (D'Cruze et al., 2007).

Trap-site	Season	Line	Habitat	Latitude	Longitude	Start date	Finish date	Days	Capture rate(%)
1	Wet 1	1	disturbed	12°19.72'S	49°20.54'E	17.04.05	24.04.05	7	22.1
		2	disturbed	12°19.77'S	49°20.62'E	17.04.05	24.04.05	7	5.2
		3	disturbed	12°19.80'S	49°20.62'E	17.04.05	24.04.05	7	11.7
2	Wet 1	4	Forest	12°20.24'S	49°21.27'E	26.04.05	03.05.05	7	15.6
		5	Forest	12°20.27'S	49°21.23'E	26.04.05	03.05.05	7	23.4
		6	Forest	12°20.27'S	49°21.18'E	26.04.05	03.05.05	7	24.7
3	Wet 1	7	Forest	12°20.86'S	49°21.44'E	26.05.05	02.06.05	7	2.6
		8	Forest	12°20.97'S	49°21.44'E	26.05.05	02.06.05	7	1.3
		9	Forest	12°21.09'S	49°21.48E	26.05.05	02.06.05	7	2.6
4	Dry 1	10	Forest	12°20.24'S	49°21.27'E	06.07.05	14.07.05	8	3.4
		11	Forest	12°20.27'S	49°21.23'E	06.07.05	14.07.05	8	4.5

		12	Forest	12°20.27’S	49°21.18’E	06.07.05	14.07.05	8	1.1
5	Dry 1	13	Forest	20°19.59'S	49°20.60'E	29.07.05	06.08.05	8	15.9
		14	Forest	12°19.64'S	49°20.59'E	29.07.05	06.08.05	8	13.6
		15	Forest	12°19.63'S	49°20.53'E	29.07.05	06.08.05	8	3.4
6	Dry 1	16	disturbed	12°19.58'S	49°20.71'E	11.08.05	20.08.05	8	2.3
		17	Forest	12°19.72'S	49°20.22'E	11.08.05	20.08.05	8	1.1
		18	Forest	12°19.68'S	49°20.23'E	11.08.05	20.08.05	8	1.1
7	Dry 2	19	Forest	12°20.24’S	49°21.27’E	15.10.05	24.10.05	8	4.5
		20	Forest	12°20.27’S	49°21.23’E	15.10.05	24.10.05	8	9.1
		21	Forest	12°20.27’S	49°21.18’E	15.10.05	24.10.05	8	3.4
8	Dry 2	22	disturbed	12°19.80’S	49°20.62’E	06.11.05	15.11.05	8	21.6
		23	disturbed	12°19.81’S	49°20.56’E	06.11.05	15.11.05	8	5.7
		24	disturbed	12°19.85’S	49°20.51’E	06.11.05	15.11.05	8	20.5
9	Dry 2	25	Forest	12°20.86’S	49°21.44’E	19.11.05	28.11.05	8	0
		26	Forest	12°20.97’S	49°21.44’E	19.11.05	28.11.05	8	2.3
		27	Forest	12°21.09’S	49°21.48E	19.11.05	28.11.05	8	1.1
10	Wet 2	28	Forest	12°20.24’S	49°21.27’E	10.01.06	19.01.06	8	22.7
		29	Forest	12°20.27’S	49°21.23’E	10.01.06	19.01.06	8	26.1
		30	Forest	12°20.27’S	49°21.18’E	10.01.06	19.01.06	8	30
11	Wet 2	31	Forest	20°19.59'S	49°20.60'E	22.01.06	31.01.06	8	3
		32	Forest	12°19.64'S	49°20.59'E	22.01.06	31.01.06	8	2.3
		33	Forest	12°19.63'S	49°20.53'E	22.01.06	31.01.06	8	8
12	Wet 2	34	disturbed	12°19.58'S	49°20.71'E	03.02.06	12.02.06	8	1.1
		35	Forest	12°19.72'S	49°20.22'E	03.02.06	12.02.06	8	4.5
		36	Forest	12°19.68'S	49°20.23'E	03.02.06	12.02.06	8	4.5

Methods

I. Pitfall traps

Pitfall traps are an effective method of sampling fossorial species such as burrowing skinks and blind snakes, and will also collect small terrestrial reptiles, some ground dwelling frogs, small rodents, and tenrecs. The trap consists of a bucket sunk into the ground, into which the animals drop and become trapped. A plastic drift fence runs along the top of a series of pitfall traps which channels the animals.

II. Small mammal traps

These are small rectangular metal traps designed for the live capture of small mammals. The traps are baited with either peanut butter or fruit to attract animals. As the animal enters the trap to retrieve the bait its weight causes the entrance to spring shut, thus becoming trapped. Animals captured include mouse lemurs, rodents, and some reptiles.

Procedure

Each trap-site consisted of a line of eleven pitfall traps, each 10m apart. A 100m-long plastic drift fence, that stood approximately 0.5m high, ran over the top of the pitfall traps. For each trap-site, this line of pitfall traps was repeated three times with each of the three lines located independently, approximately 50m apart. Small mammal traps were placed along each pitfall line, within approximately 4m of the line. They were placed both on the ground and on tree branches and baited using either peanut butter or fruit.

Once a trap-site was assembled, the site was disturbed as little as possible so that target species were not scared away from the area. The pitfall and small mammal traps were checked and emptied in the morning between 07:00 and 09:00 hours. To ensure no animals entered the small mammal traps in the day and died of heat exhaustion all traps were closed. The pitfall traps were checked in the afternoon between 15:00 and 17:00 hours, and the small mammal traps were opened and baited.

Captured individuals were identified, measured, and marked before release. Photographs for identification and records were taken.

Results

I. Small Mammals

(Green et al., 2007)

Seven species of small mammal were caught during surveying (Table 2). The greater hedgehog tenrec (*Setifer setosus*) and the common tenrec (*Tenrec ecaudatus*) are endemic to Madagascar and were both caught in pitfall traps. Common tenrec was observed during April to September; torpor is well documented for this species during this period. The tuft-tailed rat (*Eliurus sp.*) and shrew tenrec (*Microgale sp.*) could not be identified to species level. These species were only captured on two occasions so are believed to only be present in low numbers. It is likely that these two species are previously undocumented species or subspecies.

II. Reptiles and Amphibians

(D'Cruze et al., 2007)

In both pitfall traps and small mammal traps, a total of 18 species of reptile and amphibian were captured, all of which are endemic to Madagascar, and two are listed on CITES Appendix II (Table 3). Three of the species captured are previously undescribed species; two of which are likely to be endemic to Montagne des Français. In addition, one other species is endemic to Montagne des Français: *Paroedura lohatsara*.

Table 2. Endemism and IUCN listing of the small mammal species captured at trap-sites.

	Common Name	Latin Name	Endemism[1,2]	IUCN[3]
1	Tuft-tailed Rat	*Eliurus sp.*	R	
2	Shrew Tenrec	*Microgale sp.*	R	
3	Common Tenrec	*Tenrec ecaudatus*	E	LC
4	Greater Hedgehog Tenrec	*Setifer setosus*	E	LC
5	Black Rat	*Rattus rattus*	I	
6	Pygmy Musk Shrew	*Suncus etruscus*	I	
7	House Mouse	*Mus musculus*	I	

[1] Garbutt, N. 1999. Mammals of Madagascar. Pica Press, UK.

[2] Goodman, S.M., Ganzhorn, J.U., and Rakotondravony, D. Introduction to the Mammals, In: The Natural History of Madagascar, S.M.Goodman and J.P. Benstead (eds.) pp 1159-1186. University of Chicago Press, Chicago. Where R=Regionally Endemic, E=endemic, and I=Introduced.

[3] IUCN 2006. 2006 IUCN Red List of Threatened Species. www.iucnredlist.org (cited 21/03/07). Where LC=Low Concern.

Table 3. Endemism, CITES listings, and capture details of the species of reptile and amphibian captured at trap-sites.

	Species	Endemism[1]	CITES[2]	Total Captures	% Capture Rate
	Amphibia				
1	*Mantella viridis*	E	II	11	0.35
2	*Mantidactylus bellyi*	E		4	0.13
3	*Ptychadena mascareniensis*	E		2	0.06
4	*Stumpffia* cf. *roseifemoralis*	E		1	0.03
	Reptilia				
5	*Amphiglossus* sp. nov.	L		1	0.03
6	*Amphiglossus ardouini*	E		1	0.03
7	*Furcifer pardalis*	E	II	3	0.10
8	*Geckolepis maculate*	E		13	0.41
9	*Liophidium* sp.	L		1	0.03
10	*Liophidium torquatum*	E		2	0.06
11	*Madascincus intermedius*	E		67	2.14
12	*Madascincus stumpffi*	E		38	1.21
13	*Paroedura lohatsara*	L		16	0.51
14	*Paroedura stumpffi*	E		13	0.41
15	*Trachylepis elegans*	E		64	2.04
16	*Trachylepis tavaratra*	E		21	0.67
17	*Typhlops* sp.	E		6	0.19
18	*Zonosaurus tsingy*	E		11	0.35

[1] Glaw, F., Vences, M., 1994. A Field guide to the Amphibians and Reptiles of Madagascar, 2nd edn. Vences & Glaw Verlag, Köln. Where E=Endemic and L=Locally Endemic.

[2] UNEP-WCMC Species Database: CITES-Listed Species 2007. http://www.cites.org/eng/resources/species.html (cited 21/03/07). Where I=Appendix 1 and II=Appendix 2.

Discussion

Of the species of small mammal observed during this surveying, four species are endemic to Madagascar and two of these are listed as Low Concern on the IUCN Red List. One species is of particular interest: the tufted-tailed rat (*Eliurus sp.*). *Eliurus* species are concentrated in the eastern portion of Madagascar and occur in middle to upper montane rain forest. Only one species is noted to have dry forest associations and this is *Eliurus myoxinus*, a species whose range is best documented south of the Tsiribihina River (Garbutt, 1999). *Eliurus majori* and *webbi* are two species that are recorded at Montagne d'Ambre. Identification of the two individuals trapped in Montagne des Français was not possible and further capture of these species is required for identification. Given the high endemicity of this area, it is possible that this could be an undescribed species of *Eliurus*.

Capture rates for the 18 species of reptile and amphibian are generally low. The species captured the most include *Madascincus intermedius*, *Madascincus stumpffi*, *Trachylepis elegans*, and *Trachylepis tavaratra*. These species are fossorial and fast, thus difficult to capture by hand. This shows the importance of use of this methodology in surveying.

Mammals

I. Bats

(Robinson *et al.*, 2006)

Methods

The bat species found in Montagne des Français were sampled from April to December 2005, using both mist nets and hand held nets. Mist nets, 12m long and 4m high, were set across the stream close to camp and at the entrance to the two caves sampled. Hand nets were used to capture bats roosting in the caves. Although there are many caves within the massif, only two caves were sampled due to accessibility, health and safety and cultural reasons. Many caves in the Andavakoera region are used as burial grounds and thus not accessible. The caves sampled were at S12°19.72; E049°20.22 and S12°19.991; E049°21.178.

Results

Eight species of bat were observed/captured in Montagne des Français; two Megachiroptera and six Microchiroptera (Robinson et al., 2006) (Table 4). The two Megachiroptera were *Rousettus madagascariensis*, which was captured in mist nets and four occasions, and *Pteropus rufus* which was observed foraging on fruit in trees close to camp and in Andavakoera. The six Microchiroptera were all captured by hand nets whilst roosting in the caves. Both *Hipposideros commersoni* and *Triaenops auritus* were only encountered once during the study period, implying that these species are rare within the massif.

Discussion

Several species of bat observed in Montagne des Français are endemic to Madagascar and classified on the IUCN Red List (Table 4). *Emballonura sp* is found in the forest of Northern Madagascar and is classified as Vulnerable on the IUCN Red List. The Malagasy mouse-eared bat (*Myotis goudoti*) is endemic to the island and is a widespread forest species known from Ankarana Special Reserve. *Miniopterus gleni* is present in all areas except the Sambirano Region but is known to be present in Ankarana Special Reserve. Local populations of this species are regarded as particularly vulnerable. *Miniopterus manavi* is found across Madagascar but is classified as Data Deficient on the IUCN Red List. *Triaenops auritus* is a species only known from the Antsiranana region and is classified as Data Deficient on the IUCN Red List.

Of the Megachiroptera, *Pteropus rufus* is listed as Vulnerable by the IUCN Red List. This species was observed foraging in Montagne des Français, but the roosting site is situated on the Pain de

Sucre, a large island in the Bay of Diego. This species is hunted for food and was seen for sale at the market in Antsiranana.

Table 4. The endemism, IUCN listing and CITES listing of the bat species observed in Montagne des Français.

Species	Endemism	IUCN
Pteropus rufus	E	VU
Rousettus madagascariensis	E	LR
Emballonura sp.	E	VU
Hipposideros commersoni		LR
Truaenops auritus	R	DD
Miniopterus gleni	E	
Miniopterus manavi	E	DD
Myotis goudoti	E	LR

[1] Garbutt, N. 1999. Mammals of Madagascar. Pica Press, UK.
[2] IUCN 2006. 2006 IUCN Red List of Threatened Species. www.iucnredlist.org (cited 21/03/07). Where VU=Vulnerable, LR=Lower Risk, and DD=Data Deficient.

II. Lemurs

(Green et al., 2007)

Methods

Surveying the lemur species of Montagne des Français consisted of casual sightings both during the day and night. In addition active searches for nocturnal lemurs were conducted during night walks and small mammal traps at trap-sites.

Results

During the 15 months of survey work four species of lemur were observed (Green *et al*., 2007) (Table 5). The most regularly and easily spotted lemur was the crowned lemur (*Eulemur coronatus*). This species was regularly seen around the camp throughout the 15 months. They were most commonly seen during dawn and dusk when they were most active, but their activity during the night was evident from regular vocalisations, including guttural grunting and alarm screeches. They were especially prevalent around camp from September to January when the mangoes were present. During this time the troop became habituated to our presence and would come down from the trees to drink at the stream.

Observations were made of two troops of crowned lemurs; one troop of 8-10 were observed within the canyon then another troop of 8-12 were observed around camp. These two troops were often separated by over 1km. Crowned lemurs normally occur in troops of 5-15 individuals and have small home ranges. There is also often large overlaps between troops so it is likely that these observations were of two separate troops. However, it is possible that the two troops were sub-groups of foraging individuals from the same troop.

A troop of only 5-7 individuals was observed on three occasions at the French fort within the mountain. This is of significance for tourism as many tourists visit the French fort. During a satellite camp at Berambô a large troop of 10-20 lemurs was regularly observed around the camp and surrounding forests.

Another species of lemur regularly observed was the mouse lemurs (*Microcebus tavaratra*). This species is nocturnal and was most commonly sighted during solitary foraging. Individuals were regularly spotted in torch light around camp. During a satellite camp one individual was spotted on the main …….

Table 5. The endemism, IUCN listing and CITES listing for the species of lemur observed in Montagne des Français.

	Common Name	Latin Name	Endemism[1,2]	IUCN[3]	CITES[4]
1	Aye-Aye	*Daubentonia madagascariensis*	E	EN	I
2	Crowned Lemur	*Eulemur coronatus*	R	VU	I
3	Northern Sportive Lemur	*Lepilemur septentrionalis*	R	VU	I
4	Northern Rufous Mouse Lemur	*Microcebus tavatra*	R		I

[1] Garbutt, N. 1999. Mammals of Madagascar. Pica Press, UK.

[2] Goodman, S.M., Ganzhorn, J.U., and Rakotondravony, D. Introduction to the Mammals, In: The Natural History of Madagascar, S.M.Goodman and J.P. Benstead (eds.) pp 1159-1186. University of Chicago Press, Chicago. Where R=Regionally Endemic and E=endemic.

[3] IUCN 2006. 2006 IUCN Red List of Threatened Species. www.iucnredlist.org (cited 21/03/07). Where EN= Endangered and VU=Vulnerable.

[4] UNEP-WCMC Species Database: CITES-Listed Species 2007. http://www.cites.org/eng/resources/species.html (cited 21/03/07). Where I=Appendix 1 and II=Appendix 2.

path leading up to the French fort and on two occasions an individual was spotted at Berambô. Small mammal traps at trap-sites captured three individuals. Two of these individuals were captured on base camp and the third was captured at the French fort. These enabled the measurement and positive identification of the species.

The third species of lemur to be observed in Montagne des Français is the northern sportive lemur (*Lepilemur septentrionalis*). This species is solitary and nocturnal, spending the day in tree holes and foraging during the night. Sightings of this species were difficult due to its shy and cryptic nature but individuals were spotted in the trees on and around base camp. Although not sighted at Berambô, nightly vocalisations provided evidence of the presence of this species.

The aye-aye (*Daubentonia madagascariensis*) was observed on one occasion in Montagne des Français. This species is very elusive and occurs at low densities. The sighting of an aye-aye was in November 2005 in the trees above the centre of the base camp, where it was feeding on mangoes. The individual was sighted just after dusk accompanied by a troop of crowned lemurs. The crowned lemurs displayed no aggressive behaviour and the Aye-aye was undeterred by the large number of noisy crowned lemurs.

Discussion

The observations of four species of lemur within Montagne des Français is of great significance to the mountains preservation. Both the crowned lemur and the northern sportive lemur are listed as Vulnerable on the IUCN Red List. This is due to a decline in area of occupancy and quality of habitat, and actual or potential levels of exploitation. These species are only found in the northern tip of Madagascar, where the area and quality of their habitat is declining. In many areas these species

are hunted for food; within the Andavakoera region of Montagne des Français it is fady to hunt lemurs yet evidence of hunting is present. Lemur traps were encountered throughout the area. A Malagasy man who tracks the lemurs using dogs was observed passing through camp on several occasions. In addition a French resident of a hotel near Antsiranana was seen with a gun and dogs within the mountain.

The aye-aye is listed as Endangered by the IUCN Red List due to a decline in area of occupancy and quality of habitat, actual or potential levels of exploitation, and populations becoming severely fragmented. The aye-aye is a cryptic, nocturnal species, and there is little accurate data on the species. It is currently classified as Endangered by the IUCN Red List but as further data is gathered on the species, showing an extension in its range, this level of designation is being called into question. The aye-aye is widespread across Madagascar and inhabits a variety of native forest types, but as it only occurs at low densities this is not a common species. The major threat to this species is habitat fragmentation. Due to its occurrence at low densities large tracts of forests are required to sustain viable populations. This is of concern for this species within Montagne des Français as anthropogenic activity in this area has lead to its isolation within forest fragments.

In comparison with Montagne d'Ambre and Ankarana Special Reserve, Montagne des Français has few species of lemur. Montagne d'Ambre holds eight species of lemur and Ankarana has 10 species. As this study was concentrated in a small area it is possible that other species of lemur exist in other areas of the mountain. Some residents claim the existence of the western grey bamboo lemur (*Hapalemur griseus*) within Montagne des Français. Surprisingly, no Sanford's brown lemur (*Eulemur fulvus sanfordi*) were observed in Montagne des Français. This species lives sympatrically with crowned lemurs in both Montagne d'Ambre and Ankarana.

III. Carnivores

(Green et al., 2007)

Methods

The sighting of viverrid species relied upon casual sightings. As most viverrid species are nocturnal night walks were regularly conducted.

Results

The only confirmed sighting of any viverrid species was the ring-tailed mongoose (*Galidea elegans dambrensis*). Two sightings of this species were on camp diurnally in October and February. A family of ring-tailed mongoose were also sighted during the satellite camp at Berambô.

Discussion

The Ring-tailed mongoose is endemic to the north of Madagascar and is classified as Vulnerable on the IUCN Red List. The main pressures exerted on this species are loss of habitat due to deforestation, and competition with the introduced small Indian civet (*Viverricula indica*), feral cats, and dogs which are all widespread across Madagascar.

Although the ring-tailed mongoose is the only viverrid species to have been sighted during this work, it is possible that other species of carnivore are present in Montagne des Français. Many residents of the massif claim the presence of both the fosa (*Cryptoprocta ferox*) and small Indian civet (*Viverricula indica*). It is also possible that the fanaloka (*Fossa fossana*) and falanouc (*Euleres goudotii*) are present in the massif. Further work focusing on these species is necessary to positively confirm their existence in Montagne des Français.

IV. Other Mammals

One other species of mammal was observed indirectly in Montagne des Français, the bush pig, *Potamochoerus larvatus*. This species was not directly observed due to its secretive and mainly

nocturnal activity but was observed indirectly through its excavation of large areas of the forest floor. On one occasion animals were heard fleeing and a large area where this species had been digging was found. Although the direct observation of the species is preferred, these indirect observations and confirmation from residents of the mountain strongly suggest the presence of this species in Montagne des Français.

Birds

(Green et al., 2007)

Methods

Both MacKinnon's list technique (MacKinnon & Phillips, 1993) and casual observations were employed for surveying the avifauna of Montagne des Français. MacKinnon's lists comprised of the observer recording a pre-determined number of species to complete one list. A 10-species species list was used in this work as this provides the most accurate results in species poor environments and Malagasy avifauna is known to be relatively species poor (Watson *et al*., 2005; Herzog *et al*., 2002; Trainor, 2002). Species were only recorded if a positive visual identification could be made and at least one researcher was present with volunteers for each list to reduce observer bias. Casual sightings were recorded if the species, location, or behaviour of the species was of significance.

Results

A total of 63 species of bird were recorded for Montagne des Français of which 24 (38%) are endemic to Madagascar (Green et al., 2007) (Table 6). An additional 10 species were observed at the mangrove forest at the mouth of the River Betahitra, of which one species is endemic to Madagascar: Madagascar swamp warbler (*Acrocephalus newtoni)* (Green *et al*., 2007) (Table 7). The mangrove forest was observed to be a roosting site for several hundred cattle egrets (*Bubulcus ibis*). From observations at the French Fort the roost site is at the point of the mangrove forest that was furthest towards the sea, suggesting the presence of a threat from the land side of the mangroves, possibly human disturbance.

Two of the species observed are introduced species; helmeted guineafowl (*Numida meleagris*) and the common myna (*Acridotheres tristis*). The helmeted guineafowl was likely introduced from Mozambique as a domestic species but has since established as wild populations. Within Montagne des Français two populations of 15-20 helmeted guineafowl were observed; one population in the Andavakoera region and the other at Berambô. Being large gregarious birds it is likely that this introduced species will be in direct competition with, and have the ability to out-compete, native endemic species. Yet, throughout Madagascar this species is under extreme pressure from hunting and numbers are steeply declining (Langrand, 1990). The common myna was introduced from India and southeast Asia in the second half of the nineteenth century to control locusts. This species is an indicator species of degradation and as forest area is reducing, the range of this species is increasing. In Montagne des Français this species has only been observed in the highly degraded land on the north-western edge of the mountain. If deforestation and agricultural land continue to increase in area the range of this species will advance further into the massif.

The presence of the breeding Madagascar buzzard (*Buteo brachypterus*) was confirmed through the observation of parents attending nests within the faces of the canyon near camp. This is unusual behaviour for the Madagascar buzzard as nests are usually built within trees. This adaptation could be a result of the lack of suitable trees in the area, the presence of a predator such as Madagascar harrier hawk (*Polyboroides radiatus*) or fosa (*Cryptoprocta ferox*) making tree nests unsafe, or simply the use of safe and abundant nesting spaces within the cliffs. The Madagascar harrier hawk was observed raiding nests within trees. One individual was observed raiding the nests of Sakalava Weaver (*Ploceus sakalava sakalava*). The Madagascar harrier hawk clung onto the branches of the baobab, turned upside down, and entered its head into the long tunnel entrance of the Sakalava weaver nests. The individual went form nest to nest searching for chicks.

During this study distinct seasonal variations were observed for two migratory species; broad-billed roller (*Eurystomus glaucurus glaucurus*) and Madagascar lesser cuckoo (*Cuculus rochii*). During the austral winter (May-August) these species migrate to East Africa. During this study broad-billed roller were observed in Montagne des Français between November and April. The Madagascar lesser cuckoo was not seen or heard calling between June and August.

The abundance of the species recorded using MacKinnon's list technique was calculated. Figures 1 and 2 show the difference in the abundance of species found in semi-degraded and degraded forests. Those species found mainly in semi-disturbed forest and of low abundance are under great pressure from habitat loss. This includes Madagascar lesser cuckoo (*Cuculus rochii*), peregrine falcon (*Falco peregrinus*), Madagascar starling (*Hartlaubius auratus*), Madagascar pygmy kingfisher (*Ispidina madagascariensis*), Madagascar crested ibis (*Lophotibis cristata*), western scops owl (*Otus madagascariensis*), and hook-billed vanga (*Vanga curvirostris*).

Table 6. The Endemism, CITES listing, and Abundance of the bird species observed in Montagne des Français.

	Species				**Abundance**	
	Scientific name	**English name**	**Endemism[1]**	**CITES[2]**	**Degraded**	**Semi-Degraded**
1	*Accipter francesii*	France's Sparrowhawk	B	II	0.01	0.03
2	*Acridotheres tristis**	Common Mynah	I		-	-
3	*Agapornis cana*	Grey-Headed Lovebird	E	II	0.11	0.23
4	*Apus barbatus*	African Black Swift	B		0.06	0.03
5	*Apus melba*	Alpine Swift	B		0.03	0.03
6	*Ardeola ralloides**	Squacco Heron	B		-	-
7	*Asio madagascariensis**	Madagascar Long-Eared Owl	E	II	-	-
8	*Bernieria madagascariensis*	Long-Billed Tetraka	E		0.09	0.06
9	*Bubulcus ibis*	Cattle Egret	B	III	0.04	0
10	*Buteo brachypterus*	Madagascar Buzzard	E	II	0.10	0.26
11	*Calicalicus madagascariensis*	Red-Tailed Vanga	E		0.01	0.06
12	*Caprimulgus enarratus**	Collared Nightjar	E		-	-
13	*Caprimulgus madagascariensis**	Madagascar Nightjar	B		-	-
14	*Centropus toulou*	Madagascar Coucal	B		0.29	0.26
15	*Cisticola cherina*	Madagascar Cisticola	B		0.08	0
16	*Copsychus albospecularis*	Madagascar Magpie-Robin	E		0.76	0.42
17	*Coracina cineria*	Ashy Cuckoo-	B		0.13	0.19

		Shrike				
18	*Coracopsis nigra**	Lesser Vasa Parrot	B	II	-	-
19	*Coracopsis vasa*	Greater Vasa Parrot	B	II	0.28	0.26
20	*Corvus albus**	Pied Crow	B		-	-
21	*Corythornis vintsioides*	Madagascar Malachite Kingfisher	B		0.09	0.06
22	*Coua cristata*	Crested Coua	E		0.20	0.32
23	*Cuculus rochii*	Madagascar Lesser Cuckoo	M,B		0.04	0.29
24	*Cyanolanius madagascarinus*	Blue Vanga	B		0.06	0.10
25	*Cypsiurus parvus*	African Palm Swift	B		0.01	0.03
26	*Dendrocygna bicolor**	Fulvous Whistling Duck	B		-	-
27	*Dicrurus forficatus*	Crested Drongo	B		0.89	0.74
28	*Dryolimnas cuvieri*	White-Throated Rail	B		0.03	0
29	*Eurystomus glaucurus*	Broad-Billed Roller	M,B		0.49	0.45
30	*Falco eleonorae**	Eleonora's Falcon	M	II	-	-
31	*Falco Newtoni*	Madagascar Kestrel	B	I, II	0.33	0.23
32	*Falco peregrinus*	Peregrine Falcon	B	I, II	0.04	0.10
33	*Falculea palliata*	Sickle-Billed Vanga	E		0.03	0.03
34	*Foudia madagascariensis*	Madagascar Red Fody	B		0.43	0.29
35	*Hartlaubius auratus*	Madagascar Starling	E		0.04	0.23
36	*Hypsipetes madagascariensis*	Madagascar Bulbul	B		0.90	1.00
37	*Ispidina madagascariensis*	Madagascar Pygmy Kingfisher	B		0	0.03
38	*Leptopterus chabert*	Chabert's Vanga	E		0.20	0.06
39	*Lonchura nana*	Madagascar Mannikin	E		0.16	0.26
40	*Lophotibis cristata*	Madagascar Crested Ibis	E		0	0.03
41	*Merops superciliosus*	Madagascar Bee-Eater	B		0.16	0.26
42	*Milvus aegypyius*	Yellow-Billed Kite	B		0	0.03
43	*Mirafra hova*	Madagascar Bush Lark	E		0.03	0
44	*Motacilla flaviventris*	Madagascar Wagtail	E		0.01	0
45	*Nectarinia notata*	Long-Billed Green Sunbird	E		0.03	0.03
46	*Nectarinia*	Souimanga Sunbird	B		0.62	0.81

	souimanga					
47	*Neomixis tenella*	Common Jery	E		0.30	0.42
48	*Nesillas typica*	Madagascar Brush-Warbler	B		0.04	0.06
49	*Newtonia brunneicauda*	Common Newtonia	E		0.11	0.35
50	*Numida meleagris*	Helmeted Guineafowl	I		0.03	0
51	*Oena capensis*	Namaqua Dove	B		0.09	0
52	*Otus madagascariensis*	Western Scops Owl	E		0	0.06
53	*Phedina borbonica*	Mascarene Martin	B		0.34	0.32
54	*Ploceus sakalava*	Sakalava Weaver	E		0.54	0.03
55	*Polyboroides radiatus*	Madagascar Harrier-Hawk	E	II	0.11	0.03
56	*Saxicola torquata**	Stonechat	B		-	-
57	*Streptopelia picturata*	Madagascar Turtledove	B		0.22	0.10
58	*Terpsiphone mutata*	Madagascar Paradise Flycatcher	B		0.09	0.06
59	*Treron australis*	Madagascar Green Pigeon	B		0.13	0.19
60	*Turnix nigricollis*	Madagascar Buttonquail	E		0.14	0.26
61	*Upupa marginata*	Madagascar Hoopoe	E		0.23	0.16
62	*Vanga curvirostris*	Hook-Billed Vanga	E		0	0.06
63	*Zosterops maderaspatana*	Madagascar White-Eye	B		0.06	0.16

* indicates species that were observed by incidental observation and not using MacKinnon list census technique.

[1] Hawkins, A.F.A. and Goodman, S.M. 2003. Introduction to the Birds. In: The Natural History of Madagascar, S.M.Goodman and J.P. Benstead (eds.) pp 1019-1044. University of Chicago Press, Chicago. Where B=breeding, I=introduced, M=migrant, and E=endemic.

[2] UNEP-WCMC Species Database: CITES-Listed Species 2007. http://www.cites.org/eng/resources/species.html (cited 21/03/07). Where I=Appendix 1 and II=Appendix 2.

Table 7. The species list and endemism of the bird species observed in the mangrove forest.

	Species		
	Scientific	**Vernacular**	**Endemism**[1]
1	*Acrocephalus newtoni*	Madagascar Swamp Warbler	E
2	*Ardea cinerea*	Gray Heron	B
3	*Butorides striatus*	Green-backed Heron	B
4	*Egretta alba*	Great Egret	B
5	*Charadrius marginatus*	White-Fronted Plover	B
6	*Charadrius pecuarius*	Kittlitz's Plover	B
7	*Egretta dimorpha*	Dimorphic Egret	B
8	*Numenius phaeopus*	Whimbrel	M
9	*Sterna caspia*	Caspian Tern	B
10	*Actitis hypoleucos*	Common Sandpiper	M

[1] Hawkins, A.F.A. and Goodman, S.M. 2003. Introduction to the Birds. In: The Natural History of Madagascar, S.M.Goodman and J.P. Benstead (eds.) pp 1019-1044. University of Chicago Press, Chicago. Where B=breeding, I=introduced, M=migrant, and E=endemic.

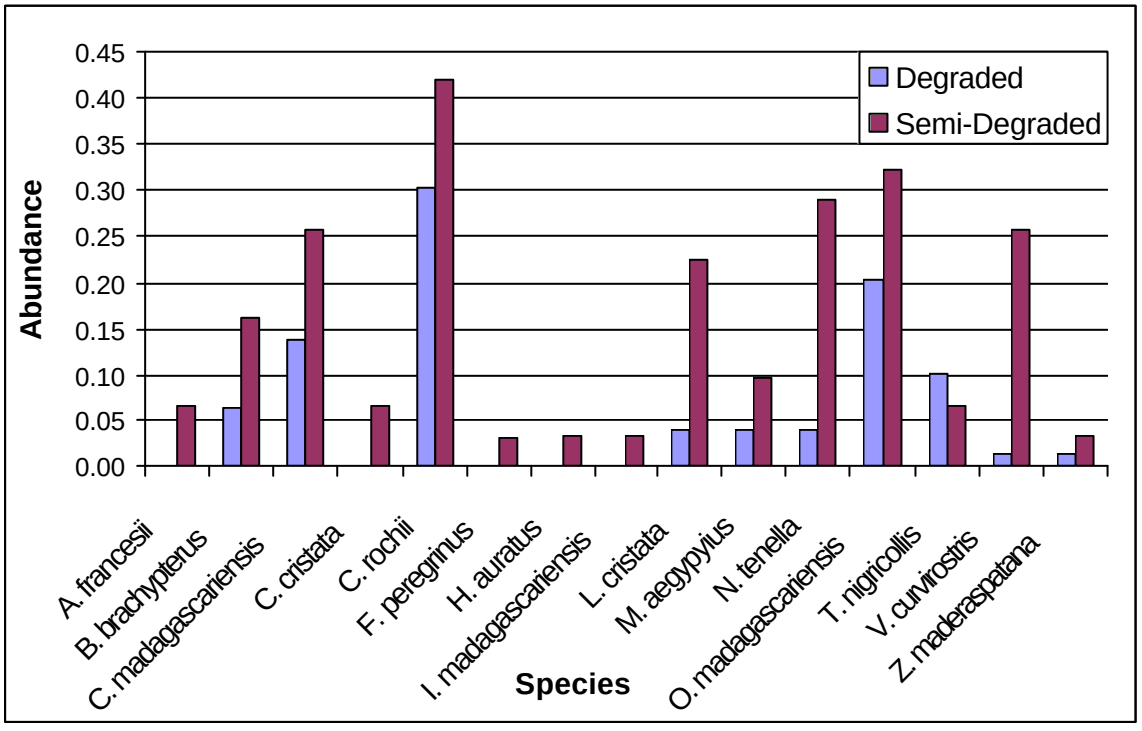

Figure 1. Species found more often in semi-degraded forest than degraded forest.

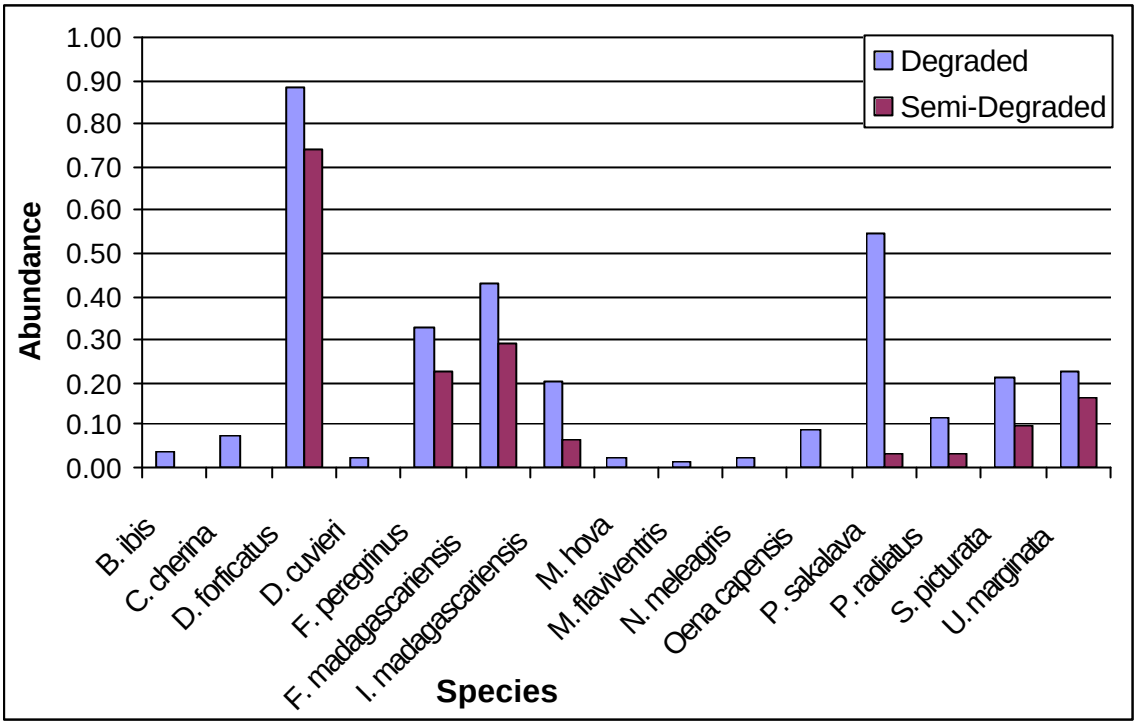

Figure 2. Species found more often in degraded forest than semi-degraded forest.

Discussion

In comparison with the nearby larger and extensively studied reserves of Montagne d'Ambre and Ankarana, with 77 and 92 species respectively, this initial avifaunal study reveals that Montagne des Français, with 63 species, is relatively species rich. Of the 63 species 24 are endemic to Madagascar and one is listed on the IUCN Red List: the Madagascar crested ibis (*Lophotibis cristata*) is listed as Near Threatened. This species is of concern due to declining numbers as a result of the reduction of habitat area and quality, along with human persecution. Crested ibis are appealing and easily hunted due to its size and behaviour of foraging on the ground. Within Montagne des Français three pairs of Crested Ibis were seen. Two pairs were observed in the Andavakoera region and the other pair was seen during the satellite camp at Berambô. Of the two pairs in the Andavakoera region, one pair was regularly observed in a particular area of forest near camp. There was confirmation of the breeding success of this pair through the sighting of a juvenile crested ibis. The other pair was observed on two occasions, April and May 2006, foraging in a large dry river bed.

Three of the species observed in Montagne des Français are listed on CITES Appendix I due to persecution for the trade in caged birds: family Psittacidae; greater vasa parrot (*Coracopsis vasa*), lesser vasa parrot (*Coracopsis nigra*), and grey-headed lovebird (*Agapornis cana*). Within the Andavakoera region of Montagne des Français grey-headed lovebirds are numerous, especially around rice and maize plantations. Greater vasa parrots were also numerous especially near the dry river bed. In this location both lesser and greater vasa parrots were present in large numbers.

Two species to note are the long-billed tetraka (*Bernieria madagascariensis*) and collared nightjar (*Caprimulgus enarratus*). The long-billed tetraka is a forest species that is rarely found adjacent to degraded areas (Langrand, 1990). Yet within the Andavakoera region this species was abundant and often seen within degraded areas. The collared nightjar is a secretive and rare species that is found in undisturbed rainforest and some dry deciduous forest (Langrand, 1990). Yet this species was observed within the canyon, a highly degraded area.

Reptiles and Amphibians

(D'Cruze et al., 2007)

Three methods were used to sample reptile and amphibian species; pitfall traps, active searches, and casual collections. The pitfall traps were constructed from buckets which were sunk into the ground to a depth of 27mm, so that the rim was flush to the ground. The top internal diameter measured 290mm, whereas the bottom internal diameter measured 220mm. To prevent the buckets flooding, 2mm diameter holes were punched into the bases. A fence was constructed to direct the herptiles into the pitfall traps. The fence, which was 0.5m in height, was constructed from plastic sheeting and wooden stakes. It was buried to a depth of 50mm using leaf litter and positioned in such a way that it cut directly across the middle of the pitfall traps (D'Cruze *et al*., 2007). A total of 36 traps were placed at 10m intervals along 36 transect lines each measuring 100m. These transects traversed a number of habitat and microhabitat types including forest and disturbed sites. Active searches were conducted both nocturnally and diurnally and involved searching a specific area for reptiles and amphibians. These searches lasted approximately three hours each and were predominantly conducted close to existing trails, river banks and ridges where search paths could be identified. It was also ensured that they covered a wide range of altitudinal conditions within Montagne des Francais to investigate the different prevailing habitats (D'Cruze *et al*., 2007). Additionally, several altitudes were covered in the sampling sites ranging from 140m, base camp, to 320m. This enabled an evaluation of the species diversity in relation to elevation (D'Cruze *et al.*, 2007)

Results

During this study nine amphibian and 52 reptile species were recorded in Montagne des Français; consisting of one species of chelonian, 28 species of lizard, 23 snakes, and nine anurans (D'Cruze et *al*., 2007) (Tables 8 and 9). Three species of reptile and one amphibian represent undescribed species. 23 species (37.7%) recorded during the biodiversity surveys were found to be rare whereas 14 were found to be abundant and common (23% each). Ten species (16.4%) were found to be abundant. The highest proportion of species recorded were found in relatively undisturbed areas of the forest (60.7%), whereas 8.2% of the total number of species recorded were found in anthropogenically altered non-forest habitats. The five species found in these non-forest habitats were *Acrantophis madagascariensis, Hoplobatrachus tigerinus, Langaha madagascariensis, Pelusios castanoides* and *Ramphotyphlops braminus*. 26.2% of species occurred in both habitats. Terrestrial habitats had a higher abundance of species in comparison with arboreal habitats, as well as a combination of both, where 31 species (50.8%), 14 (23%) and 9 (14.8%) were recorded respectively (Green *et al.*, 2007). Six species were observed in both semi-aquatic and terrestrial habitats (9.8%) and one species, *Pelusios castanoides* (1.6%), was recorded in semi-aquatic habitats alone (Green *et al.*, 2007). Only 13 of these species had previously been recorded in Montagne des Français (Glaw and Vences 1994; Ramanamanjato *et al*., 1999**;** Glaw *et al*., 2001; Vences *et al*., 2004; Glaw *et al*., 2005a, 2005b). The previously unknown species of the Montagne des Français herpetofauna represents 78.7% of the all those sampled in this survey.

Species diversity was also analysed in relation to elevation bands. Maximum herpetofaunal species diversity was recorded at mid-elevations in the 100-199 m band, where 51 species were recorded. This is contrasted with the lowest species diversity of 15 species, which was found in the 300-399 elevation band (D'Cruze *et al*., 2007).

Table 8. Endemism, IUCN listing, and CITES listing for the species of amphibian observed in Montagne des Français.

	Species	**Endemism[1]**	**IUCN[2]**	**CITES[3]**
	Amphibia			

	Microhylidae			
1	*Stumpffia* cf. *roseifemoralis*	E		
2	*Stumpffia* sp. 1	E		
	Ranidae			
3	*Hoplobatrachus tigerinus*	E		II
4	*Ptychadena mascareniensis*	E		
	Mantellidae			
5	*Aglyptodactylus* sp. nov.	E		
6	*Boophis tephraeomystax*	E		
7	*Laliostoma labrosum*	E		
8	*Mantella viridis*	E	CR	II
9	*Mantidactylus bellyi*	E		

[1] Glaw, F., Vences, M., 1994. A Field guide to the Amphibians and Reptiles of Madagascar, 2nd edn. Vences & Glaw Verlag, Köln.
[2] IUCN 2006. 2006 IUCN Red List of Threatened Species. www.iucnredlist.org (cited 21/03/07). Where CR=Critically Endangered.
[3] UNEP-WCMC Species Database: CITES-Listed Species 2007. http://www.cites.org/eng/resources/species.html (cited 21/03/07). Where I=Appendix 1 and II=Appendix 2.

Table 9. Endemism, IUCN listing, and CITES listing for the species of reptile observed in Montagne des Français.

	Species	**Endemism[1]**	**IUCN[2]**	**CITES[3]**
	Reptilia			
	Chamaeleonidae			
1	*Brookesia ebenaui*	E		II
2	*Brookesia* sp. nov.	L		II
3	*Brookesia stumpffi*	E		II
4	*Furcifer pardalis*	E		II
5	*Furcifer petteri*	E		II
6	*Furcifer oustaleti*	E		II
	Gekkonidae			
7	*Blaesodactylus boivini*	E		
8	*Ebenavia inunguis*	E		
9	*Geckolepis maculate*	E		
10	*Geckolepis* sp.	E		
11	*Hemidactylus frenatus*	E		
12	*Hemidactylus mercatorius*	E		
13	*Lygodactylus heterurus trilineigularis*	E		
14	*Paroedura lohatsara*	L		
15	*Paroedura stumpffi*	E		
16	*Paroedura* cf. *homalorhina*	L		
17	*Phelsuma madagascariensis grandis*	E		II

18	*Phelsuma abbotti checkei*	E		II
19	*Uroplatus ebenaui*	E		II
20	*Uroplatus sikorae sameiti*	E		II
	Gerrhosauridae			
21	*Zonosaurus boettgeri*	E		
22	*Zonosaurus tsingy*	E		
	Scinicidae			
23	*Amphiglossus* sp. nov.	L		
24	*Amphiglossus ardouini*	E		
25	*Madascincus intermedius*	E		
26	*Madascincus stumpffi*	E		
27	*Trachylepis elegans*	E		
28	*Trachylepis tavaratra*	E		
	Boidae			
29	*Acrantophis madagascariensis*	E	VU	I
30	*Sanzinia madagascariensis volontany*	E	VU	I
	Colubridae			
31	*Alluaudina bellyi*	E		
32	*Dromicodryus bernieri*	E		
33	*Dromicodryus quadrilineatus*	E		
34	*Heteroliodon fohy*	L		
35	*Ithycyphus miniatus*	E		
36	*Langaha pseudoalluaudi*	E		
37	*Langaha madagascariensis*	E		
38	*Leioheterodon madagascariensis*	E		
39	*Liophidium torquatum*	E		
40	*Liophidium* sp.	L		
41	*Liopholidophis lateralis*	E		
42	*Liopholidophis stumpffi*	E		
43	*Liopholidophis martae*	L		
44	*Madagascarophis colubrinus*	E		
45	*Madagascarophis* sp. nov.	L		
46	*Mimophis mahfalensis*	E		
47	*Pseudoxyrhopus quinquelineatus*	E		
48	*Stenophis inopinae*	E		
49	*Stenophis granuliceps*	E		
	Typhlopidae			
50	*Typhlops* sp.	E		
51	*Ramphotyphlops braminus*	E		
	Pelomedusidae			
62	*Pelusios castanoides*	E		

[1] Glaw, F., Vences, M., 1994. A Fieldguide to the Amphibians and Reptiles of Madagascar, 2nd edn. Vences & Glaw Verlag, Köln.

[2] IUCN 2006. 2006 IUCN Red List of Threatened Species. www.iucnredlist.org (cited 21/03/07). Where CR=Critically Endangered.
[3] UNEP-WCMC Species Database: CITES-Listed Species 2007. http://www.cites.org/eng/resources/species.html (cited 21/03/07). Where I=Appendix 1 and II=Appendix 2.

Discussion

The reptile fauna of Montagne des Français has shown to have a high level of endemicity, 96.7%. Only *Ptychadena mascareniensis* and *Leioheterodon madagascariensis* have been found on other Indian Ocean Islands. Of the species recorded, eight species are likely to be endemic to Montagne des Français; *Amphiglossus* sp. nov., *Brookesia* sp. nov., *Heteroliodon fohy*, *Liophidium* sp., *Liopholidophis martae*, *Madagascarophis* sp. nov., *Paroedura* cf. *homalorhina* and *Paroedura lohatsara* (4 of which are undescribed).

Three species recorded in Montagne des Français are listed on the IUCN Red List. These are the two species of Boidae, *Acrantophis madagascariensis* and *Sanzinia madagascariensis volontany*, and *Mantella Viridis*. Both species of Boidae are listed as Vulnerable by the IUCN due to a decline in extent of occurrence and quality of habitat and due to actual or potential levels of exploitation. These species are often killed through fear or for the use of their skin for leather products. Due to this persecution both species are listed on CITES Appendix I. During the wet season both species of Boidae were captured in the Andavakoera region, especially around camp, and *Sanzinia madagascariensis* was captured during the camp at Berambô. Breeding confirmation was attained through the capture of juveniles. Within Montagne des Français locals were frightened of these species and would avoid them rather than kill them.

Mantella Viridis is listed as Critically Endangered on the IUCN Red List following an observed reduction of the population. During the dry season within the Andavakoera region *Mantella viridis* were only observed in one location which is under extreme pressure from zebu grazing. Yet during the wet season *Mantella viridis* were numerous, and found in both semi-degraded and degraded forests and in rice plantations.

In addition, 14 species are listed on the CITES appendices (Tables 8 and 9). These restrictions are mostly in place due to exploitation for the pet trade.

In terms of species diversity associated with elevation bands, it can be seen that species richness was highest at the mid-elevation band. However, due to the fact theat base camp was situated in the mid-elevation band, sampling may have been predominantly conducted there. Thus a degree of bias must be considered regarding the results. Further data collection is clearly required to solidify any results regarding diversity within elevation bands (D'Cruze *et al.*, 2007).

Socio-economic Surveys

(Green *et al.*, 2007)

Methods

Interviews with locals within Montagne des Français had two objectives; to investigate sources of anthropogenic activities within the massif and compliment our raw biodiversity data collected in the field with local knowledge. To investigate sources of anthropogenic activity in the massif semi-structured interviews were conducted using a set of questions on arable farming, pastoral farming, and hunting. A total of 18 interviews were conducted; nine in Andavakoera and nine in the canyon near camp. Interviewees ranged in age between 25 and 70+, five were female and 13 were male. To determine local knowledge on the biodiversity in the massif, pictures from books and Malagasy names for species were presented to the interviewees. For each species, the interviewees were asked

if the species was present in the massif now, or in the past. The 25 interviews were conducted on this second topic and the interviewees ranged in age from 19-78, all except one were male.

Results

Anthropogenic Activities

I. Resource Use

One of the main activities of those living within the canyon is charcoal production. This activity involves felling trees and slowly burning them in an underground pit. Stacks of charcoal sacks ready to be transported for sale in Antsiranana (for approximately 15,000FMg) were regularly seen throughout the massif. The largest stack of charcoal sacks seen was approximately 80 sacks. Interviewees stated that one person usually has at least two charcoal pits which are cycled to ensure a constant supply of charcoal. 78% of the 18 interviewees produced charcoal and 67% of those sold a proportion of the charcoal in order to make a profit (Green *et al.*, 2007).

Another activity of those living within the canyon is the felling of hard wood trees. The wood is cut into blocks and transported to Antsiranana for sale. This activity is extremely laborious, involving cutting trees by axe and transporting the wood by hand down from the massif. There was constant felling activity throughout the study period but this activity is less prevalent than charcoal production and even less so as a commercial product, with 72% of interviews producing it and 22% of them selling it (Green *et al.*, 2007).

II. Arable Farming

Villagers in Andavakoera grow a wide variety of produce; rice, maize, coconut, cassava, chilli pepper, papaya, beans, sweet potato, mango, lemon, banana and jack fruit. Within the village there is an extensive plantation of *Annona sp*. which produces a fruit like a custard apple, called Koni Koni. A typical plot of land ranges between 1-2 hectares.

The majority those people living and working within the canyon near camp had moved into the area within the last 10 years from the towns of Ambilobe (200km), Vohemar (100km), Maronsetra (300km) and Moramanga (500km). These are among an increasing number of people relocating to the massif, attracted by the wealth of virgin fertile land. Interviewees from the canyon grow mostly maize and rice which was transported to Antsiranana for sale. Interviewees identified a switch in land use from rice to maize cultivation necessitated by the shorter rainy seasons of recent years.

III. Pastoral Farming

Within Andavakoera the main activity is zebu farming. This is evident from the large area around the village that has become cleared of vegetation through zebu grazing. The zebu from the village roamed freely within the forests between camp and the village.

Chickens are kept as a source of protein and as a source of income through raising chicks and selling them in Antsiranana.

IV. Hunting

Hunting was practiced for subsistence means as well as a profit making initiative. 78% of the interviewees regularly hunted, while the remaining 22% contribute to the bush meat market through purchasing the products (Green *et al.*, 2007). A wide variety of animals in the forest were identified as being hunted and eaten. The most significant bird species being hunted was the crested ibis (*Lophotibis cristata*), which is listed as Vulnerable on the IUCN Red List. Many other species are hunted using nooses, traps, catapults and poison. Both adults and children were often seen within the forests armed with catapults.

Species of mammal that are hunted include bush pig (*Potamochoerus larvatus*), which was hunted by 17% of interviewees. Several species that were hunted appear on the IUCN Red List, including greater hedgehog tenrec (*Setifer setosus*) and the common tenrec (*Tenrec eucaudatus*) which were hunted by 50% of the interviewees (Green *et al.*, 2007). The ring tailed mongoose (*Galidia elegans*) and the flying fox (*Pteropus rufus)* were also found to be hunted regularly. Methods used include spears to catch bush pig, dogs to sniff out Tenrec and ring tailed mongoose, and nets for flying foxes.

Although hunting and the exploitation of natural resources was found to be common practise to many of the interviewees a significant proportion, 83%, were in favour of Montagne des Francais being placed under more stringent regulations to further the protection of the massif (Green *et al.*, 2007).

Generally people in Andavakoera had a more varied diet than those living in the canyon. Many in the canyon either hunt very little or not at all and supplement their diet with meat from Antsiranana. Some villagers in Andavakoera work as fishermen, thus supplementing their diet with fish. A fresh water turtle (*Pelusios castanoides*) was observed being prepared for a meal in Andavakoera.

The animals associated with being fady to hunt or eat varied greatly according to the family of the interviewee. Common fady include the crowned lemur (*Eulemur coronatus*), the crested drongo (*Dicrurus forficatus*), the pied crow (*Corvus albus*), and the Madagascar coucal (*Centropus toulou*). Some people listed tenrecs, bush pig and flying fox as fady.

Biodiversity Knowledge

Of the species observed by Frontier most interviewees confirmed their existence. Exceptions to this are the common jery (*Neomixis tenella tenella*) (12/25), common newtonia (*Newtonia brunneicauda*) (10/25), Madagascar buzzard (*Buteo brachypterus*) (16/25), Madagascar cisticola (*Cisticola cherina*) (10/25), Madagascar white-eye (Zosterops maderaspatana) (12/25), and mascarene martin (*Phedina borbonica madagascariensis*) (6/25) (numbers after each species show the number of interviewees out of 25 giving a positive response to the species presence). All these species are easily viewed within Montagne des Français. This suggests a possible lack of knowledge of the interviewees, or poor translation or picture quality. Few interviewees confirmed the presence of shy and less abundant species such as blue vanga (*Cyanolanius madagascarinus*) (10/25), eleonora's falcon (*Falco eleonorae*) (11/25), long-billed green sunbird (*Nectarinia notata notata*) (14/25), Madagascar brush warbler (Nesillas typica typical) (11/25), Madagascar long-eared owl (*Asio madagascariensis*) (14/25), peregrine falcon (*Falco peregrinus*) (8/25), and red-tailed vanga (Calicalicus madagascariensis) (13/25).

Bird species presented to interviewees that were not recorded by Frontier included species from the eastern rainforests and western dry deciduous forests. Some species were misidentified for a species that exists in Montagne des Français and looks very similar; dark newtonia (*Newtonia amphichroa*) (10/25), green jery (*Neomixis viridis*) (10/25), red-capped coua (*Coua* ruficeps) (17/25), red-breasted coua (*Coua ruficeps*) (16/25), and red-fronted coua (*Coua reynaudii*) (10/25). Results that are of particular interest are the common sun-bird asity (Neodrepanis coruscans) (22/25), Madagascar fish-eagle (*Haliaeetus vociferoides*) (15/25), and Madagascar serpent eagle (*Eutriorchis astur*) (19/25). The Common Sun-bird Asity is a rainforest species yet 22 of the 25 interviewees claimed it exists in Montagne des Français. Although the souimanga sunbird (*Nectarinia souimanga*), which exists in the mountain, is the same size and has the same beak shape it is unlikely that this result was misidentification as colouration differs greatly. The existence of two species of eagle in Montagne des Français is an exciting prospect. It is possible that the Madagascar fish-eagle may have been observed within the massif as this species is found in Montagne d'Ambre, and along the coast near

Antsiranana. Yet, due to its rarity and habitat preference of undisturbed rainforest it is unlikely that the Madagascar serpent eagle would be found in Montagne des Français.

Of the four species of lemur already observed by Frontier in Montagne des Français only two interviewees knew of the existence of the aye-aye (*Daubentonia madagascariensis*), and only 10 interviewees agreed with northern sportive lemur (*Lepilemur septentrionalis*) being present. Both these species are cryptic and nocturnal, which could explain the lack of knowledge. When questioned about the western grey bamboo lemur (*Hapalemur griseus occidentalis*), 24 out of 25 interviewees claimed its presence in Montagne des Français. Comments were made on the presence of this species in a different area of the massif from that studied during this work that contained bamboo forests.

Only one carnivore, ringed-tailed mongoose (*Galidia elegans dambrensis*), was observed by Frontier in Montagne des Français yet there were reports of other carnivores existing within the mountain. The results of the interviews show that it is possible that the fanaloka (*Fossa fossana*) (10/25), fosa (*Cryptoprocta ferox*) (13/25), and small Indian civet (*Viverricula indica*) (14/25) exist in Montagne des Français.

Conclusion

This survey work carried out by Frontier in the Montagne des Français found high levels of endemism amongst mammals (66%), reptiles (96%) and amphibians (100%) as well as moderate levels of endemism within the birds (38%). In addition, eight species of reptile observed during this study are believed to be endemic to Montagne des Français. The rarity and vulnerability of many of the species observed is reflected in the large number listed on IUCN Red List and CITES Appendices (Table 10).

Table 10. Summary of the biodiversity of the fauna observed in Montagne des Français.

	No. Species	**No. Endemic**	**No. IUCN Red Listed**	**No. CITES listed**
Mammals	21	14	9	4
Birds	63	24	1	3
Reptiles	52	50	2	12
Amphibians	9	9	1	2

This survey was conducted from April 2005 to June 2006, thus the surveying enclosed all seasons. This was an important aspect of the study as many species were only observed during the wet season, including migratory birds and species which enter torpor during the dry season. The exception to this was the surveying of bats, which ceased in December 2005 due to lack of the post-exposure rabies vaccine. Although eight species of bat were observed it is likely that both the number of species and the number of individuals will increase during the wet season. This is implied though the large amount of guano present in the caves.

The majority of the surveying was conducted in the Andavakoera region of Montagne des Français; with short term rapid surveying conducted in surrounding areas. The area covered by this survey is relatively restricted in comparison to the total area of the massif. The Andavakoera region is a highly degraded area due to the proximity to Antsiranana. Through further surveying covering both a greater area of the massif and less degraded areas it is highly likely that further species will be discovered. Given the high endemicity of the area, this extension of the survey work is crucial as additional undescribed species may be present in the massif.

This faunal biodiversity assessment of Montagne des Français has revealed the conservation importance of the massif. The massif currently receives limited protection and is only designated a Temporary Protected Area. The proximity of the massif to Antsiranana is resulting in vast anthropogenic pressure upon the massif. Results of interviews with local residents show that the main pressures are charcoal production and agricultural practices. In addition, interviewees also commented on the large number of people moving into the massif attracted by its virgin fertile land and proximity to Antsiranana. Given this pressure and the presence of high levels of faunal diversity and endemism permanent protection of the massif is required to prevent the drastic effects of further habitat loss.

To successfully protect the massif will require effective management due to high level of anthropogenic activity already present. This needs to involve the prevention of further habitat loss due to anthropogenic activities. As a result of the threat of increasing human residency within the

massif, the number of both legal and illegal residents must be restricted, which will include monitoring of the number of residents. In addition to monitoring the anthropogenic activities within the massif, the faunal and floral diversity must be monitored. To establish the current level of faunal diversity in Montagne des Français a continuation of this study is needed that will result in a comprehensive survey of the fauna for the whole massif. From these initial levels changes in faunal diversity can then be monitored effectively. This is also the case for floral diversity and habitat loss. Without initial assessment of the current extent of habitat lost the management of future habitat loss is not viable. As monitoring of faunal and floral diversity, habitat loss, and levels of residency will be long-term and labour intensive training of personnel is required. As many students of the University of Antsiranana have been involved in projects within the massif there is the possibility of involving students in long-term monitoring.

Another aspect of the conservation of Montagne des Français which requires effective management and monitoring is eco-tourism. The proximity of Montagne des Français to Antsiranana not only facilitates the exploitation of resources but also eco-tourism. Although the presence of tourists within Montagne des Français could have drastic effects on the flora and fauna without effective management and monitoring, it could also be beneficial. The supply of tourists is already present from tour companies bringing tourists to visit Montagne d'Ambre and Ankarana. With effective management this tourism could provide residents of Montagne des Français with a source of income and thus greatly reduce their need of exploiting resources for profit. This could be achieved through the implementation of community based eco-tourism, in which the community of Montagne des Français would receive all the profit from tourism. Montagne des Français not only holds diverse and endemic flora and fauna, but also great potential for the future.

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