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MADAGASCAR CONSERVATION & DEVELOPMENT

INVESTING FOR A SUSTAINABLE NATURAL ENVIRONMENT FOR FUTURE GENERATIONS OF HUMANS, ANIMALS AND PLANTS OF MADAGASCAR

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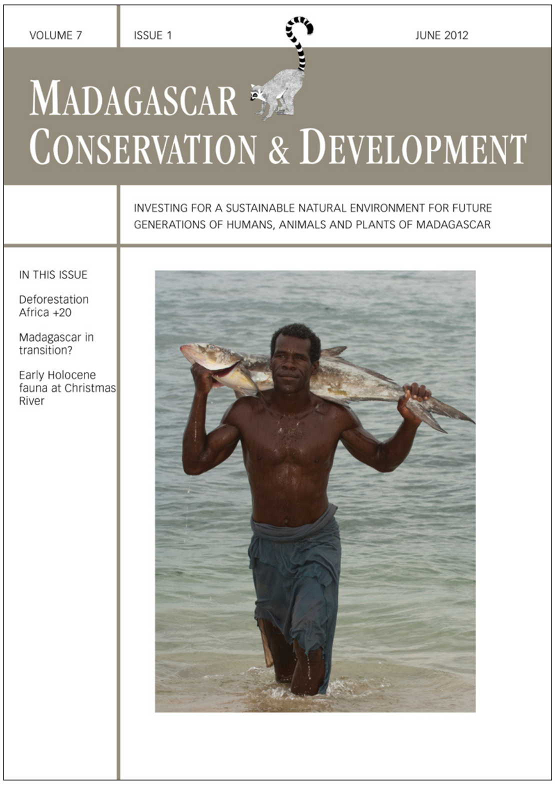

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EDITORIAL

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Madagascar, (in) dépendante depuis 1960

Il est légitime d'espérer, qu'un jour, les relations franco-malgaches se normaliseront. Mais force est de constater que ce n'est pas encore le cas. Bien qu'illégitime, l'impact de la politique française sur Madagascar est réel.

On a espéré que la fin de la Françafrique viendrait avec l'élection de Nicolas Sarkozy en 2007. Ce dernier avait laissé espérer un véritable bouleversement des relations franco-africaines un an plus tôt à Cotonou (Bénin) : « Je crois indispensable de faire évoluer, au delà des mots, notre relation ». Il plaide dans ce fameux discours pour plus de franchise et de transparence, pour moins de domination et de paternalisme. Bref, pour « une relation nouvelle, assainie, décomplexée, équilibrée, débarrassée des scories du passé » qui se baserait sur la défense des libertés et des droits de l'Homme en Afrique. Et, effectivement, les premiers signes sont assez encourageants. La nomination de Rachida Dati et de Rama Yade au gouvernement sonne comme un véritable espoir de reconnaissance de la diversité raciale et culturelle. S'ajoute à cela la disparition de la « cellule africaine » de l'Élysée. Les questions africaines sont alors rattachées à la cellule diplomatique, ce qui signifie qu'elles devraient être traitées comme n'importe quelle autre question de politique étrangère (Hugon 2010). Mais, nul besoin de le rappeler, le discours de Dakar, dont le mépris a choqué toute l'Afrique, vient briser tout espoir de dialogue d' « égal à égal » en 2007.

Les espoirs se portèrent alors sur son successeur. La campagne présidentielle française fut un événement très suivi en Afrique, parfois même plus qu'en France. François Hollande, à quelques exceptions près, fut le candidat des Africains et représentait un nouvel espoir de relations normalisées entre l'Afrique et la France.

Peut-être le nouveau président français va-t-il concrétiser ce souhait, peut-être va-t-il nous décevoir comme son prédécesseur, là n'est pas la question. Car en cette journée de fête nationale, alors que Madagascar honore la mémoire de ceux qui se sont battus et sont morts par milliers pour son indépendance, ma réflexion se porte sur les actions menées à Madagascar plutôt que sur l'attente passive des premiers pas de François Hollande en Afrique. On fête aujourd'hui les 52 ans d'indépendance de l'Île. Mais qui leurre-t-on ? Certes, ce n'est plus l'ère coloniale, le régime de l'indigénat n'est plus. Certes, Madagascar n'est pas le cas le plus emblématique de la Françafrique, on trouve des cas bien pires sur le continent. Certes, de nouveaux acteurs apparaissent à Madagascar et contestent l'omniprésence de l'ancienne colonie. Mais peut-on pour autant parler d'indépendance ?

Si la liberté se limite à être moins exploité qu'avant, moins que d'autres et à avoir le droit de choisir son bourreau, alors, peut être, Madagascar est-il un État indépendant. Nul besoin de souligner l'ironie de cette définition.

Car si on ne peut que se réjouir de la multiplication des partenaires de Madagascar, on ne peut ignorer les risques du passage de la Françafrique à la Chinafrique. Avec l'arrivée au pouvoir de Marc Ravalomanana, la Chine, historiquement déjà bien implantée sur la Grande Île, devient un partenaire majeur de Madagascar. Plus généralement, le nouveau président se tourne largement vers l'Asie comme nouveau partenaire et modèle économique. Quand arrive la crise de 2009 et qu'Andry Rajoelina prend le pouvoir, ces relations se multiplient. Car les bailleurs traditionnels de Madagascar gèlent leurs aides financières en attendant qu'un gouvernement démocratique reprenne le pouvoir. Or, la Chine, au nom du refus de l'ingérence, ne prend pas en compte la situation politique de ses partenaires économiques. Les relations qui existaient déjà entre Madagascar et la Chine se renforcent et se multiplient alors. En contrepartie de l'exploitation des ressources primaires, minières et pétrolières, la Chine s'implique dans des aides humanitaires, sanitaires, dans l'éducation, dans la construction d'infrastructures (Harnay et Louis 2011). Or cette exploitation des ressources malgaches est souvent ni équitable ni durable, parfois même pas légale. L'exploitation du bois de rose sur laquelle Madagascar Conservation & Development (MCD) fut le premier à publier est un des exemples de cette exploitation immodérée (Randriamalala et Liu 2010).

Certes, la Chine est peut-être un moindre mal, ne serait-ce que parce que c'est un « bourreau choisi » alors que la France s'était imposée. Mais, laissons nous aller à un peu d'idéalisme en cette journée nationale et espérons, qu'un jour, Madagascar, au lieu de pouvoir choisir son bourreau, pourra choisir l'indépendance.

En cela, MCD espère agir, avec modestie, à son échelle et avec ses moyens. Dans ce numéro comme dans les précédents, la qualité des articles est garantie par le processus du comité de lecture qui élimine ou améliore les articles, certifie la véracité des données et la pertinence des analyses. Les sujets des articles sont très divers. Avec des sujets scientifiques comme « Suivi du Gecko *Phelsuma serraticauda* (Reptilia : Squamata : Gekkonidae) dans la région Atsinanana » de Christian Randrianantoandro et al. « Toponyms for centers of endemism in Madagascar » de Lucienne Wilmé et al. et « Early Holocene fauna from a new subfossil site: A first assessment from Christmas River, south central Madagascar » de Kathleen M. Muldoon et al., nous espérons faire progresser les connaissances essentielles à la recherche et à la science. Avec des Spotlights comme « Revisiting deforestation in Africa (1990–2010): One more lost generation » de Jean-Roger Mercier ou « Love me tender, transition vers où » de Solofo Randrianja, nous invitons à des réflexions et débats sociaux et politiques.

Nous n'avons ni l'ambition ni les moyens de bouleverser la société. Nous agissons à notre échelle et proposons, en publiant ces articles et en nous assurant de leur qualité, des bases aux débats sur la conservation et le développement à Madagascar.

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SPOTLIGHTS

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Revisiting deforestation in Africa (1990–2010): One more lost generation

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ABSTRACT

This spotlight revisits the dynamics and prognosis outlined in the late 1980's published in *Déforestation en Afrique*. This book on deforestation in Africa utilized available statistical data from the 1980's and was a pioneering self-styled attempt to provide a holistic viewpoint of the ongoing trends pertaining to deforestation in Africa; of root causes and of the challenges facing the conservation community. Here, the same author searches for an explanation for the 'commercial fiasco' of that book and uses the recent Global Forest Resource Assessment (GFRA) published by the Food and Agriculture Organisation (FAO, 2010), concluding that (i) this overall prognosis turned out to be slightly pessimistic vs. the actual forest evolution as recorded by FAO, but that (ii) deforestation in Africa still continues at 0.5 % per annum, and (iii) success stories are few and Africa remains the continent where major deforestation continues apace. The analysis of ten African countries 'at risk' because of a combination of an economic slump coupled with a high deforestation rate confirms a likely relationship between these two factors. The lack of attention paid to deforestation in Africa raises concerns that "throwing money at the problem" – the best solution that the international community has found so far – may not be constructive in the least.

RÉSUMÉ

Un livre publié en 1991, écrit par l'auteur utilisait les données statistiques des années 80 sur les forêts Africaines, données telles que disponibles à l'époque. Ce livre représentait une première tentative, non sollicitée, de fournir un tableau holistique des tendances d'alors sur la déforestation en Afrique, de s'interroger sur les causes profondes de ce phénomène et sur les défis à relever dans ce domaine. Dans le présent article, l'auteur cherche les raisons du fiasco commercial du livre et effectue des calculs sur les données les plus récentes sur les forêts Africaines telles que publiées par l'Organisation des Nations-unies pour l'agriculture et l'alimentation (plus connue sous son sigle anglais FAO). Les principales conclusions de cette rapide analyse sont (i) les projections sur le futur des forêts Africaines effectuées dans le livre de 1991 se révèlent marginalement pessimistes par rapport à la réalité observée (sur la base des projections de 1991 et sur une base 100 en 1990, les forêts africaines restantes seraient dans une fourchette de 77,2 à 87,8 %, l'indice réel étant 89,9 %), cependant, (ii) la déforestation continue en Afrique à un rythme de 0,5 % l'an, peu différent du taux de 0,56 % dans les années 90 et (iii) les réussites Africaines dans la lutte contre la déforestation sont peu nombreuses et ce continent reste le plus exposé à ce fléau dans le monde. Le livre de 1991 contenait également l'identification de dix pays Africains « à risque » à cause d'un cumul de stagnation économique et de fort taux de déforestation. L'observation des évolutions récentes confirme que ces pays sont « mal partis ». En conclusion, l'auteur regrette le manque d'attention à la déforestation en Afrique, au moment même où le monde célèbre « Rio + 20 » ; l'auteur craint également que la tactique habituelle de la communauté internationale « jeter de l'argent sur le problème » ne fonctionne pas, des causes fondamentales de la déforestation comme le manque de politiques publiques efficaces ou la corruption endémique réclamant plus que de l'argent pour être extirpées.

'DÉFORESTATION EN AFRIQUE'

The book *Déforestation en Afrique* (Mercier 1991) outlined the basic features of African forests, available statistics pertaining to these forests, and the common uses of forest products and services, in both a local and global context. A chapter on forests in relation to development described the vicious circle linking stagnant poverty with resource degradation (specifically deforestation) in Africa. Mercier (1991) also outlined future scenarios of deforestation and identified ten African countries particularly at risk when it comes to environmental degradation coupled with a stagnant, impoverished economy. He concluded the book with a set of broad-based policy recommendations.

Commercially the book was a disaster, in contrast to a couple of books the same author had written during the preceding decade. The first book (Mercier 1978) is regarded as having had healthy sales in spite of being just as difficult to read and it dealt with a more provincial topic (Mercier 1978). Why then, was interest so low in *Déforestation en Afrique*? A possible cause may have been a low quality of writing (though this is no different from the 1978 book), much of the explanation can be found in the following cumulative factors:

- A slow start and slow development of a systematic approach of centralised forest knowledge (including field data collection and processing) for Africa by the international community;

- a low point in terms of environmental concerns (the 1973 energy shock had passed, liberalism was booming and the 'environmental fiesta' in Rio and the baptism of 'sustainable development' were still under preparation);
- a lack of interest on the part of francophone readers for world (including African) matters;
- the lack of academic and other institutional support for Mercier's 1991 book;
- lack of support for the book meant that Mercier (1991) was unable to fully explore and research preliminary documentation on the topic particularly outlining the complexity of deforestation in Africa;
- a key finding was the lack of appropriate and consistent measurement of deforestation, particularly in Africa. Another key finding was the lack of sensitivity of decision-makers to multi-sectoral approaches to the deforestation phenomenon.

REVISITING 'DEFORESTATION IN AFRICA'

Twenty years later, most of the progress has been on the studies and measurements of deforestation in Africa and Madagascar, but the deforestation itself continues: in some places – especially in the strategic Congo Basin – on primary forests in an irreversible manner. The questions that come to mind while revisiting the 1991 book are "how predictable were deforestation trends during the late 1980's and how many of these predictions materialised?" In 2012, courtesy the UN system and modern technology, improved knowledge about forests and deforestation trends worldwide and particularly in Africa, is 'a mouse click' away from any analyst. For this spotlight, I have accessed FAO's Global Forest Resource Assessment database (FAO 2012) to compare notes with what I had written up in the late 1980's.

I had hoped that the said assessment would be of the same accuracy as the Millennium Ecosystem Assessment (2005) which mobilized over 1,310 experts into action and led to millions of $US being spent, only to realize that GFRA was actually based on a set of questionnaires sent by FAO to individual governments. The statistical tables that were used for this article was compiled from that data. The compilation was more comprehensive than the 1982 data that what was used in preparation of the 1991 book (Mercier 1991), but it was still not based on thorough field studies. So, while the 2012 GFRA figures are more comprehensive than the 1982 FAO figures, we are still far from having an accurate representation of forest cover, forest quality and forest loss in Africa.

One key trend was noted during the preparation of the 1991 book: the annual rate/extent of forests on a country-by-country base. By 1982, the total forest cover estimated was about 640 Mha for the 42 countries that had produced some data on the status of their forests. A key distinction was made between open and closed forest cover. According to Neeff et al. (2006) "a forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground, or open forest". Closed forests are the 'ecologist's dream', since they are richest in terms of biodiversity and have kept their ecological assets more or less intact (e.g., Wright and Muller-Landau 2006, Foley et al. 2007). The split between the estimated extent of closed and open forests was 31/69 in terms of Africa on a continental level.

In the much more factual and comprehensive recent global forest assessment, the African 'countries' (the presence of Mayotte, La Réunion and Western Sahara included in the list) for which data were measured and compiled, the overall forest cover for 1990 was given as being 749 Mha. The difference between the FAO 1982 and the 2012 estimates are a combination of

- unreported forestry data in some key countries in 1982 (e.g., no reported extent of open forest area in South Africa, then in full apartheid mode) and
- absence of about a dozen countries, including most of the islands around Africa, in the 1982 FAO compilation. For the purpose of the present article, a relative comparison will help establish how much of Mercier's 1991 prognosis was accurate or inaccurate.

While the 2000 reality was close to 1991 book's projections (actual index is 94.7 and the figures from the 1991 book are 91.6–95.7), the 2010 reality (89.9 % of the 1990 forests remaining in Africa) is less pessimistic than the book's 77.2–87.8 % estimate. Indeed, the recent FAO figures show a very slight decrease in annual deforestation rate on the continent from the 1990's (0.56 % per annum) to the 2000's (0.50 % per annum). This decrease in degradation rate

- is hardly statistically significant and
- has little bearing of the future evolution of African forests (forest cover projection in 2050 is 555 Mha for 0.5 % and 535 Mha for 0.56 %). This very slight reduction in rate of degradation is not commensurate with the huge amount of public resources that have been invested in forest management in Africa during the last two decades. FAO (2010) mentions yearly spendings of 361 M $US in 2000 and 578 M US$ in 2005 (most recent figure available).

There are four basic motivations to this revisiting:

- Relevance of forests for sustainable development in Africa
- The obvious failure of public policies in protecting the remaining forests in Africa
- Deforestation as a reflection of incompetent resource management
- The long journey before we have a clearer picture of deforestation.

Forests, open or closed, play an important role in sustainable development in Africa. Closed forests are particularly vulnerable because of the irreversible nature of their destruction, and have been often heralded by the Big Non Governmental Organisations (BINGOs) as being of particularly key significance on various levels, but open forests also play an important role, not just as carbon sink, but also as providers of vital products and services to local human populations (Falconer 1990, Ambrose-Oji 2003, Ticktin 2004, Topa 2005). This has been demonstrated on a subregional basis (Cleaver 1992) as well as on a regional scale. The authors of "The changing wealth of nations" (World Bank 2011), for instance, estimate that, for Sub-Saharan Africa as a whole, Non-Timber Forest (NTF) asset value was 44 % of timber value in 1995 and 83 % in 2005, respectively.

On the failure of forest conservation policies, I have possibly been too impressed by 'experts' or economists whom I had met in international circles, many of them claiming that they had found – and helped to implement – the solution to sustainable forest development. The reality, unfortunately, is that deforestation in Africa continues, whether at the rate of the FAO/GFRA tables, or not. Ergo, public policies have failed in most African countries. The struggle for practices and policies that actually conserve forests and their assets on the ground has to continue.

Deforestation is just one facet of incompetent and shabby resource management at the local, national and sub-regional level. Whether 'effective' policies or not are designed by African countries or by the international community, what matters is what happens in the field. This holds true for forest/tree management and for other natural resource management. In the field, a combination of low public service presence and of generalised corruption involving both the corrupters and the corrupted, minimises impact of policy implementation. This was well illustrated in the case of rosewood exploitation in Madagascar (Randriamalala et al. 2011, Schuurman and Lowry 2009).

Last but not least, the new forest statistics as presented in FAO's 2012 GFRA – while they are more detailed than 1982's figures – still lack the accuracy and consistency needed to properly understand deforestation and sustainable forest management. This gap ought to be dealt with rapidly, especially since data collection technology is evolving fast, e.g., with the increased use of new sensors (Tucker and Townshend 2000, Achard et al. 2002, Murphy 2009).

TWENTY YEARS OF DEFORESTATION

My first conclusion for this spotlight: as was predicted in Mercier's 1991 book (Mercier 1991), the situation for Africa's forests worsened between 1990 and 2010. Of practically all parts of the world (except Central America, which has a whopping -1.23% per annum), Africa has had, during the 2005–2010 period, the highest deforestation rate: an average of -0.5 % per annum, while Asia experiences a net growth during the period (+0.29 % per annum, largely due to forest plantation efforts in China (Liu and Diamond 2005, Turnbull 2007), Latin America (-0.41 % per annum) loses forest, but less rapidly than Africa and more than Oceania (-0,31 % when Australia is removed from the statistics. Australia has a high deforestation rate (-0.61 %) and more than 75% of the forest cover in Oceania.). However, decrease of forest cover in Africa between 1990 and 2010 was slightly smaller than what Mercier (1991) originally suggested.

Second conclusion: the tables have turned. Several of the worst 'culprits of deforestation' have actually become noticeable guardians of the forests (the ratio 'deforestation rate 2002–2010/deforestation rate 1982' was used as a guide), while in other countries, the reverse seems to have occurred. Tunisia, Rwanda and Morocco now have a net positive forest cover growth. Other countries (Mauritania, Mozambique, Benin, Burkina Faso, Burundi, Sudan, Niger, Madagascar, Liberia, Malawi, Algeria, and Kenya) have experienced a substantial decrease in their deforestation rate. In the remaining African countries deforestation rates have worsened. With appropriate resources, a finer analysis would look at positive and negative cases and learn from the policies that have been put in place. In passing, it may be worth noting that Gabon, consistent with the Bongo family's dislike for statistics, has produced amazing reports on its forest cover: a consistent (and suspiciously rounded figure) between 2000 and 2010.

Third conclusion: Mercier (1991) proposed a set of criteria to identify countries 'at risk' in Africa – key factors included low income per capita, low literacy, high pressure on arable land and low forest cover. The 1991 prediction was based on a multi-criteria analysis involving five variables (GDP per capita, Illiteracy rate, Ratio Forest area/land area, Forest area/capita, Population/area balance, and a ratio by FAO relating the actual per country agricultural land availability per capita with an 'ideal' reference ratio).

Based on the compilation of these variables for the 42 countries assessed, Mercier (1991) identified the following ten countries as being most at risk in terms of forest loss: Malawi, Chad, Nigeria, Rwanda, Gambia, Somalia, Burundi, Burkina Faso, Mauritania, Niger, in increasing order of risk (i.e., Niger being the most at risk). The 2010 statistics actually confirmed this. The ten countries, on the average, are 40 % under the average 2010 GDP/capita in Africa. If Nigeria, a large country with its 150+ million inhabitants, is removed from the list, the nine remaining countries have a GDP/capita of 67 % below the continental average.

In summary the 1991 projections and guestimates (Mercier 1991) were far from wrong. The impact of alarm bells was extremely low, and the same African deforestation problem as in the late 1980's still lies ahead, only much worse so. Would a new answer be acronyms and money? In the early 1990's, international development experts could simply mention the Tropical Forest Action Plan (TFAP) and, later, an oversubscribed Congo Basin Forest Fund. What will the new answers be?

AS A MATTER OF CONCLUSION

The 1991 book (*Déforestation en Afrique*) is the work of a lone ranger and, at the end of the day the accuracies or inaccuracies in the book matter little, since no-one really acted to the findings and recommendations. At the very least, I would ensure that a new book's conclusions would be vetted by a multidisciplinary panel of scientists and practitioners.

Secondly, during the drafting of a new version of that book, I would take a much harder and closer look at the economic, social, environmental and cultural roles that trees and forests play in the daily life of ordinary African people, including, but not limited to, forest-dependent people. I would review the multiple ex-post evaluations made of community forest management projects and programs as well as of logging certification and control practices. Last but not least, I would analyse the fate of primary forests, focusing on specific, concrete trends and situations. For instance, much more attention would be paid to certain very worrying situations, like the whopping 2.94 % of per annum primary forest loss in Central African Republic (CAR). Once raised to an empire status, with the complicity of several western governments, France being unfortunately in the lead, CAR is now distanced from international public attention and away from the main air traffic zones. According to FAO figures, the annual rate of primary forest destruction in CAR increased from 2.16 % during the 1990's to 2.94 % during the 2005–2010 period. If that latter rate remains constant, half of the CAR primary forest, or 1.2 Mha, will be lost during the coming two decades – more so if the deforestation rate continues to increase. I would also classify the primary forest in Nigeria as nonexistent, as it decreased from 1.5 Mha in 1990 to a 'non significant' level in 2010.

Thirdly, I would ensure that the published version, using the Internet, floods the large institutions and the BINGOs with recommendations put across in such a shocking manner that reactions would be essential and would have to go on record. Deforestation is too serious an issue to be handled by foresters alone, and it does concern all decision makers interested in the fate of Africa.

A cynic might say "20 years ago, we tried to blow the whistle on a possibly unwell patient (forests in Africa). In 2012, we now have the confirmation that the patient is very sick. Is that progress? The war against deforestation continues. The army is small and does not have adequate weaponry. Tons of cash will pour on green carbon funds and new forests/plantations will be planted and nurtured. But what about the forests for the people, forests that shrink due to land grabbing, timber traffickers, and the greed of the new Asian barons? My hopes are that twenty years later into the 21st century, more positive news can be reported…

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SPOTLIGHTS

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Love me tender – Transition vers où ?

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RÉSUMÉ

Depuis le coup d'État de 2009, la transition menée par Andry Rajoelina, dure malgré l'absence de tout mandat électif. Même si l'inertie de cette situation est parfois relativisée par des pressions nationales ou extérieures, elle est légitimée par la passivité de la résistance et par des promesses récurrentes d'élections futures. Cependant, ces trois années nous permettent au moins de cerner la vision des autorités actuelles quant au développement de Madagascar. Les gouvernants de facto semblent baser ce développement sur l'exploitation des ressources minières ; ils inscrivent ainsi le pays dans une politique menant à l'effondrement du reste de l'économie ainsi qu'à la dilapidation du capital environnemental et humain. Or, ce choix fait de Madagascar une victime facile de la « malédiction des matières premières » dont une minorité seulement profite et dont les conséquences à long terme sont désastreuses. L'ensemble de la société est alors amené à s'interroger sur les valeurs sur lesquelles elle entend bâtir les vertus civiques et sur la capacité de la « transition » à mener le pays sur les rails du développement durable basé sur une démocratie stable.

ABSTRACT

Following the March 2009 coup, the government led by former 'disc jockey' Andry Rajoelina, has managed to perpetuate in the absence of any elections. Several reasons explain this longevity, of which the lack of legitimacy of his undertaking which has led to passive resistance. The authorities however, do want to prepare elections to legitimize their power. Being in command of the State, these authorities benefit from the administrative privilege of organising elections. This would allow them to be elected, according to well-established mechanisms. The integration of members of the opposition into the institutions of transition illustrates the relative failure of this strategy; failure due to internal pressure and the reticence of international donors. Nevertheless these three years allow us to determine the visions that the de facto leaders hold of development on the *Grande Ile*. To achieve their goals, they count in particular on making use of the 'manna' from mining, which will flow from several mining companies in a few months. Several warning signs serve to indicate that Madagascar is a victim of the 'curse of raw materials' and will be even more so in the future. While this strengthens the militarisation of political power, this curse emerges in a worrying fashion in at least three ways: i) the collapse of the real and informal economies not linked to the mining sector; ii) the squandering of natural capital with the hurried exportation of raw materials with little value added (the resources acquired thanks to the sale of mineral and more general natural resources are currently invested in sectors that do not provide social benefits in the long term. They serve, beyond the personal enrichment of the members of the ruling class, to foster populism through a system of rents and prebends. The goal is to remain in power at the expense of sustainable development; iii) the squandering of human capital through de-scholarisation and the perpetuation of the collapse of the school and university systems, demonstrating that the training of youth is considered more of an obstacle than an asset to sustainable development. This transitional government pursues unambiguous objectives, which benefit only a minority. These objectives appear clearly in the behaviour of numerous leaders. One can therefore ask oneself on what values can society build civic virtues. This governance therefore calls into question the nature of 'transition' and its capacity to lead the country on the road to a sustainable development based on a stable democracy.

INTRODUCTION

Depuis le coup d'État de mars 2009, Madagascar est entré dans une période sombre de son histoire. Tous les indicateurs sont dans la zone rouge, ceux de l'économie et du social comme ceux de la gouvernance. La 'transition' unilatérale que les auteurs du coup de force ont tenté d'imposer a fait faillite. Tant et si bien qu'Andry Rajoelina, l'ancien 'disc jockey' qui se trouve à la tête du putsch, a dû se résigner à nommer un Premier Ministre qui n'est pas de son camp et à intégrer un certain nombre de membres de l'opposition dans les institutions mises en place à la suite du coup d'État. Trois ans après le coup de force soutenu par l'Armée, Andry Rajoelina et ses partisans mènent ainsi une guerre de tranchées pour rester aux commandes de l'État afin d'espérer se faire élire aux présidentielles dans une tradition politique malgache bien établie. Celle-ci donne un bonus à celui qui est aux commandes de la machine administrative chargée d'organiser les élections. Car il peut abuser de ses prérogatives pour capter les voix des électeurs. L'enjeu à court terme dont personne ne parle, est la manne des compagnies minières nouvellement installées dont Sherrit et QMM.

Le résultat est une transition 'dénaturée' qui traîne en longueur et qui illustre l'absence de légitimité des nouveaux dirigeants. L'économie réelle s'en trouve détériorée, permettant le pillage légalisé et illégal des ressources naturelles du pays et entamant de manière inquiétante son capital humain et environnemental. Il est permis de s'interroger sur les conséquences d'une telle situation dans la perspective d'un développement durable.

Ces trois années de conduite des affaires permettent de cerner un tant soit peu la vision que les auteurs du coup d'État ont de l'avenir de Madagascar, au-delà du sort réservé à la transition. La nécessité de trouver une sortie de crise rapide ne doit pas faire passer au second plan la vision d'un développement durable respectant les droits individuels et l'aspiration collective à une démocratie stable. Cette remarque pose la question de la fonction de la transition et de la légitimité des gouvernants actuels qui se présentent comme ceux qui peuvent conduire les 21 millions de Malgaches sur cette voie (Chauprade 2010)

ÉTAT DES LIEUX

En 2010, une étude de l'Institut National des Statistiques, un organisme gouvernemental, constate que la pauvreté s'est aggravée de manière dramatique aussi bien en milieu rural qu'en milieu urbain. Elle avait auparavant régressé et retrouvé son niveau d'avant les longues grèves de 2002 qui suivirent la dispute postélectorale. Ainsi, alors que la pauvreté ne concernait que 65 % de la population avant 2009, elle s'élève en 2010 à 80 % des 21 millions de Malgaches (Institut National de la Statistique 2011) répartis sur une île dont la surface équivaut à 2,5 fois celle du Royaume-Uni.

Toutes les régions sont touchées même si elles le sont de manière inégale. Sur les six anciennes provinces, celles de Toliara et de Fianarantsoa sont les plus durement affectées. Plus de 88 % de la population y vit en dessous du seuil de pauvreté, c'est-à-dire avec moins d'un dollar par jour. Celle d'Antananarivo est la moins touchée, si l'on peut dire, car la pauvreté y affecte 66,8 % des habitants en 2010 contre 57,7 % en 2005 (Institut National de la Statistique 2011).

Et la situation ne va pas dans le sens d'une amélioration, au bénéfice de certaines ONG qui voient dans la pauvreté un véritable fond de commerce[1]. Les autorités de facto essaient d'instrumentaliser cette pauvreté dans la logique clientéliste de distribution de prébendes. Tel est l'enjeu du retour des bailleurs de fonds internationaux et de leurs financements. Ces financements ont, pour la plupart, été suspendus après le coup d'État et sont longs à revenir malgré un début timide de reconnaissance internationale, initialement snobée par l'équipe de Rajoelina en 2009.

La pauvreté urbaine est évidemment différente de celle des campagnes, moins visible. Une étude présentée en février 2012 par l'ONG Groupe Développement Madagascar a montré que plus de 50 % des prostituées de la ville d'Antananarivo, la capitale, sont des jeunes filles âgées de moins de 18 ans. Malgré l'existence d'une législation contre l'exploitation sexuelle des mineures, le phénomène prend de l'ampleur et touche les couches les plus fragiles, témoignant de l'accroissement de la pauvreté. Cinquante-six pourcent d'entre elles résident dans les zones défavorisées, comme les bas quartiers de la capitale et débutent à l'âge de 12 ans. L'Ambassade des États-Unis évoque un phénomène plus large qui est celui du trafic humain dont la presse relate régulièrement les aspects multiformes (Anonyme 2011).

Selon la coordinatrice résidente du Programme des Nations Unies pour le Développement (PNUD) à Madagascar, Fatma Samoura, la Grande Île figure désormais avec l'Afghanistan et Haïti parmi les trois pays les plus pauvres au monde en terme de malnutrition et de déscolarisation (Raharisoa 2011). Madagascar n'a pas pu atteindre trois des objectifs du millénaire pour le développement, à savoir l'accès à l'éducation primaire pour tous, la réduction de la mortalité infantile et l'amélioration de la santé maternelle. Plus grave, le pays s'en éloigne de plus en plus.

Parallèlement se sont installées au pouvoir des mafias se spécialisant dans des activités allant du simple braquage à des organisations plus complexes aux ramifications internationales associant les plus hautes autorités de l'État. Ainsi la presse fait régulièrement état d'attaques à main armée. Le jeudi 5 avril 2012, une bande a tenu tête à la police pendant plusieurs heures à Toamasina, la deuxième grande ville de l'île. Surprise en train d'essayer de dévaliser une maison de particulier, elle a répliqué. Les échanges de coups de feu durèrent plus de quatre heures. Les armes de guerre utilisées ainsi que la quantité de munitions à la disposition de la bande montrent son degré de structuration. Dans de nombreux cas de criminalité organisée, des membres des forces armées (armée, police et gendarmerie) sont impliqués. Ils louent des armes voire organisent ce genre d'attaque˙

L'une des mafias les plus visibles est celle de la « bolabolacratie », terme venant de « bolabola » (rondin de bois de rose) dans le jargon des bucherons (Randriamalala et Liu 2010, Randriamalala 2012), mais elle n'est pas la seule. Une partie des opérateurs économiques à laquelle s'est alliée une fraction de la classe politique s'est lancée dans l'exportation d'espèces endémiques protégées, à une échelle jamais atteinte auparavant. Incapable d'endiguer le phénomène, l'État a fini par permettre l'exportation en essayant de prélever une taxe dérisoire. L'ostentation de la richesse ainsi produite rend la pauvreté d'autant plus choquante qu'elle heurte et pervertit les valeurs morales de l'ensemble de la société qui semble dilapider à la fois son capital humain et son capital environnemental, grevant pour de nombreuses générations le développement de Madagascar.

En matière de gouvernance et de démocratie, tous les indicateurs illustrent plus que jamais la défiance de la population à l'égard de gouvernants. C'est là un désaveu indirect à l'encontre d'autorités non élues qui ont pris le pouvoir et s'y maintiennent par la force. Cette défiance est aggravée par le fait qu'aucune institution ne peut sérieusement exercer de contrôle sur l'exécutif qui a suspendu tous les élus depuis le coup d'État et qui a nommé les membres du 'pouvoir législatif'[2]. Celui-ci est supposé s'incarner dans un Conseil de la Transition (CT) faisant office de parlement et un Conseil Supérieur de la Transition (CST) qui remplace le sénat.

L'article 9 d'une feuille de route laborieusement initiée par la Communauté de développement d'Afrique australe (SADC) en septembre 2011 (après l'échec de plusieurs tentatives antérieures de médiation) et signée par une dizaine de partis politiques puis ratifiée par le Conseil de la Transition, charge cette dernière instance du contrôle du Gouvernement de Transition. Mais les membres de ces institutions remplaçant les législateurs sont nommés par l'exécutif. Ce dernier bénéficie de la sorte d'une très large marge de manœuvre et d'une quasi-impunité. Il rémunère les membres de ces conseils, entretenant la culture de rente et de clientélisme. Selon la Loi de finance 2011, les salaires et avantages de ces 'parlementaires' s'élevaient à 4 400 000 Ariary mensuels (1 $US équivaut à 2 000 Ariary) pour les Conseillers Supérieurs de la Transition (sénateurs) et à 2 800 000 Ariary pour les Conseillers de la Transition (députés). Devant le scandale, la 'loi' de 2012 a réduit de moitié ces émoluments en multipliant par deux le nombre des membres de ces deux institutions, sous le prétexte d'ouverture à l'opposition. Ceux-ci sont désormais au nombre de 500 membres. Pour avoir un ordre d'idée, un instituteur payé par l'organisation des parents d'élèves touche 80 000 Ariary mensuels soit 55 fois moins qu'un membre du CST. Dans un contexte de forte déscolarisation, le salaire mensuel d'un CST pourrait payer 55 enseignants du primaire.

Il est difficile de croire que de telles institutions soient en état de contrôler de manière efficace l'exécutif qui, malgré l'inclusion de membres de l'opposition, reste sous le contrôle d'une clique téléguidée par une oligarchie militaire et économique ainsi que par un baronnât composé de vieux briscards de la politique. À l'examen de la composition de ces deux chambres, il apparaît que de nombreux membres des familles des dirigeants de la Haute Autorité de Transition (HAT) y figurent. Le maître des céans s'est pourtant permis de donner une définition toute personnelle de la démocratie lors d'une interview (Chauprade 2010) : « La démocratie ne consiste pas à laisser ceux qui se sont fourvoyés distribuer les postes à leurs amis. »

Une telle situation permet de nombreux abus. Le dernier scandale en date fut la signature en catimini d'un contrat minier avec un groupe international. Celui-ci engage l'État pour plusieurs dizaines d'années et un ministre a touché une commission de plusieurs millions de $US. Fait significatif, c'est une organisation de la société civile et non le parlement qui a révélé l'affaire. Le Centre de Développement et d'Ethique (CDE) (R. 2012) a évoqué l'existence d'une commission de 12 millions $US touchée par un ministre. Cela pour avoir assuré l'octroi d'un permis minier. Selon Serge Zafimahova, président du CDE, un tel acte s'assimile à de la trahison. Non seulement le gouvernement de transition ne doit pas engager l'État sur plusieurs dizaines d'années, mais, de plus, dans ce genre de transaction, l'État devrait gagner au moins 25 % de royalties composés de taxes diverses sur les transactions. Or dans ce cas précis, selon le CDE, il n'en gagne que 2 %. La différence est empochée par les dirigeants actuels. Certaines de ces compagnies s'empressent d'ailleurs d'exploiter ces permis de complaisance pour piller sans vergogne les ressources minières au delà de ce qui fut initialement convenu (Tsarabory 2012). Dans de telles conditions l'effectivité de l'État est tombée de -0,51 en 2007 à -0,83 en 2010, selon la Banque Mondiale (2011). Le contrôle de la corruption est passé -0,13 à -0,27 pour la même période. Logiquement, en dépit des discours sur l'instauration de la démocratie dont se targuent les auteurs du coup d'État, l'État de droit est passé de -0,33 en 2007 à -0,84 en 2010 (Banque Mondiale 2011).

Le moins que l'on puisse dire est que la légitimité des gouvernants actuels pose problème et affecte la crédibilité des élections qu'ils pourraient organiser dans un avenir prochain. L'organisation, par ces dirigeants, du référendum constitutionnel du 7 novembre 2010 est un exemple autant de leur incompétence que du maintien, voire du développement, des mécanismes de fraude (Valis 2010). Pourtant Andry Rajoelina en janvier 2011 continue de citer cette consultation comme un modèle du genre : « Vu l'expérience du dernier référendum, nous pensons être en mesure de prévoir toutes les élections durant 2011. La Transition s'achèvera donc cette année » (Razafimandimby 2011).

Les tentatives de museler l'opposition sont monnaie courante autant dans le domaine des médias que dans celui des organisations. Les autorisations de réunion publique sont systématiquement refusées aux membres et aux organisations de l'opposition qui n'ont pas accès aux médias publics. Des personnalités de l'opposition font ouvertement l'objet d'intimidations tandis que le régime organise de faux complots pour neutraliser et terroriser l'opposition sans parler de la corruption de ses leaders. Le professeur Raymond Ranjeva, ancien vice-président de la Haute Cour Internationale de Justice et ancien président de l'Université d'Antananarivo, et sa fille furent victimes de ces intimidations et ont pu échapper à une justice manipulée grâce aux pressions des chancelleries étrangères et des groupes locaux.

Les comportements des gouvernants semblent faire écho à toutes les qualifications des politistes sur le genre d'État qu'ils ont réussi à édifier. L'État voyou (*rogue state*), qualificatif utilisé par Ronald Reagan pour désigner la Libye (Schwartz 2007), renvoie à un État qui ne respecte pas les lois internationales les plus essentielles, qui organise ou soutient des attentats, et/ou viole les droits de l'Homme les plus élémentaires.

Combien de fois les dirigeants de facto n'ont ils pas renié leurs propres signatures ? Il en est de même des différents faux vrais attentats en vue d'éliminer les adversaires intérieurs tout autant que de l'expropriation des domaines privés sans aucun jugement, sans parler du rançonnage de nombreux opérateurs économiques. Ces abus sont tellement flagrants que même l'ambassadeur de France, plutôt favorable au régime, a demandé que la Force d'Intervention Spéciale, sorte de milice à la solde des gouvernants, soit dissoute (Rajaofera 2010). Certains membres du gouvernement semblent même disposer d'une milice privée.

L'État est en train de devenir une menace pour son propre fonctionnement. Bayart et al. (1997) décrivent ce phénomène en le qualifiant de criminalisation de l'État. Pour ces auteurs, la criminalisation se caractérise, entre autres, par la confiscation de l'usage légitime de la violence en faveur des stratégies d'accumulation des détenteurs du pouvoir et par l'existence d'une structure occulte et collégiale du pouvoir qui contrôle le détenteur officiel de celui-ci. L'autre caractéristique de la criminalisation de l'État est la mise en marche de 'stratégies de tensions' télécommandées par des dirigeants dans la perspective d'une restauration autoritaire. Ainsi, en est-il de la tergiversation des autorités de facto à laisser revenir Marc Ravalomanana, accusé du massacre programmé du 7 février 2009 résultant d'une tentative d'occupation du palais présidentiel et organisé selon l'un des protagonistes[3] pour cyniquement créer des martyrs, dont lui même. La criminalisation de l'État permet la prédation des ressources par des compagnies internationales ou étrangères parce que les autorités n'ont ni les moyens ni la volonté de contrôler les productions et les réserves exploitées. Et ces compagnies sont souvent l'appendice économique de l'appareil politico-diplomatique de certaines puissances. Pourtant Rajoelina cite avec chaleur quelques uns de ces États qui furent les premiers à lui accorder un certain crédit. « Plusieurs États approuvent ouvertement la transition et nous font confiance pour rétablir l'ordre constitutionnel : en premier lieu la France – et c'est évidemment un appui de poids – mais aussi le Togo, le Sri Lanka, la Thaïlande, la Syrie, etc. » (Chaupade 2010).

Après avoir considéré en 2009, Mouammar Kadhafi comme son maître et s'être précipité à Tripoli, suivant les conseils de la cellule africaine de l'Elysée, Andry Rajoelina affirme que Bachar el-Assad de Syrie compte parmi « les responsables de ces pays (qui m'ont adressé), en mon nom propre, une lettre de félicitations pour mon accession à la tête de la Haute Autorité de Transition » (Chaupade 2010). Quel beau parrainage pour un coup d'État !

Des politiques étrangères de nations faiblissantes ou émergentes, en quête de volonté ou de puissance, tentent d'exploiter sans vergogne une telle situation pour obtenir des avantages géostratégiques dans un monde en redéfinition. Pourtant Châtaigner (2006) écrivait : « Les principes d'intervention (de la France en Afrique) ne visent plus …à soutenir en priorité des 'régimes clients' mais à promouvoir des principes d'action universels comme la défense de l'intégrité territoriale, le soutien aux autorités élues et la défense des droits de l'Homme... ». Jean-Marc Châtaignier fut le premier à présenter ses lettres de créance à un gouvernement issu d'un coup d'État.

ABSENCE DE VISION OU POPULISME DÉMAGOGIQUE ?

Dans une telle configuration, quand une équipe tente de s'accrocher au pouvoir et rallonge la période de transition, il est intéressant de tenter de circonscrire la vision à long terme que les nouveaux dirigeants ont de l'avenir de Madagascar. Celle-ci transparait autant dans leurs discours que dans les non-dits de leurs calculs et des ambitions des dirigeants de facto qui tentent de légitimer leur mainmise sur le pouvoir par des élections.

Sitôt arrivé au pouvoir, Rajoelina se dépêche d'augmenter le budget de la présidence. Il passe de 79 milliards environ en 2008 à 133 milliard l'année d'après et à 265 en 2010 (Banque Mondiale 2008). Cette véritable caisse noire à sa disposition permet d'honorer certaines promesses et plus généralement d'entretenir une clientèle en dehors de tout contrôle. À quoi ce budget fut-il utilisé ? Dans un système de prébende, et vu l'absence de transparence dans la gestion de ces fonds, la logique voudrait qu'ils aient été utilisés à asseoir le nouveau pouvoir, ce qui correspond à la définition de l'autocratie. On visite en vain le site de la présidence (ou ceux des ministères) pour tenter de trouver les détails de ces dépenses. L'enveloppe allouée à la Présidence est passée de 265 milliards d'Ariary en 2010 à 68 milliards d'Ariary dans le budget 2011 ; soit une diminution de 84 %, un aveu implicite d'abus. De nombreuses dispositions de la Constitution maison de la IV^{e} République, mort-née, confirment au moins le présidentialisme sinon la propension à l'autocratie.

Dans cette logique autocratique, Andry Rajoelina ne peut qu'avoir peu confiance en ses propres collaborateurs susceptibles de profiter d'une situation sans contrôle, tentés d'aller dans la même voie que lui : « Je n'en disconviens pas, peut-être qu'il y a des responsables… qui n'ont qu'un seul but : s'enrichir au plus vite. (Aussi) …Nous avons… décidé que tout engagement supérieur à 200 millions d'Ariary passe désormais à la présidence. En tout et pour tout, je n'ai signé que 40 mandats » (Razafimandimby 2011).

La bonne gestion des finances publiques dont se targuent les dirigeants actuels n'est au mieux que l'importation des techniques managériales du secteur privé dans la gestion des finances publiques. Or celle-ci a déjà montré ses limites sous Ravalomanana, elle se caractérise par l'opacité et le pouvoir de décision d'une seule personne sans contrôle institutionnel, qui finira par déraper. On ne peut que craindre un tel dérapage quand Rajoelina expose naïvement son but « Je veux laisser des traces de mon passage au pouvoir par de grandes réalisations. Ayant le goût du défi, je suis de ceux qui voient grand dans tout ce qu'ils font. Personne ne peut, par exemple, effacer mon empreinte dans la reconstruction de l'Hôtel de ville d'Antananarivo » (Razafimandimby 2011).

Quelles peuvent donc être ces « grandes réalisations » qui pourraient être à l'origine du développement ou qui pourraient l'initier ? À la question de Chauprade (2010) : « En imaginant que vous disposiez des moyens de votre politique, quelles mesures prendriez-vous pour sortir enfin le pays du marasme ? », Andry Rajoelina propose cinq « grands chantiers de développement » pour initier ce qui n'a pas été fait « durant un demi-siècle d'indépendance » : (i) un « grand hôpital » semblable à celui qui est en cours de construction dans la ville de Mahajanga et « à terme, toutes les agglomérations seront pourvues d'un établissement de ce type répondant à des normes de qualité internationales. » (ii) « Il faut refonder complètement le système d'enseignement supérieur. » (iii) Le troisième chantier est « le retour au bon sens agricole. Alors que notre monde rural a une grande tradition de riziculture, Madagascar est devenu un pays importateur de riz ! Pour y remédier, nous avons décidé d'octroyer 30 000 hectares de terrains rizicoles à des paysans modestes. » (iv) Le quatrième chantier va de pair avec « notre programme de santé : le sport et la culture pour la jeunesse. Un pays sain est un pays sportif. À Antsonjombe sera implanté le plus grand complexe culturel de l'océan Indien. Puis, dans chaque grande ville, nous construirons un stade. » (v) Le cinquième chantier : « l'amélioration de la connectivité du pays. Nous devons, en effet, compenser notre éloignement des grands centres commerciaux et financiers de la planète (États-Unis, Europe, Asie) par des capacités de transport modernes : transport ferroviaire à l'intérieur, maritime et aérien à l'extérieur, et réseaux de communications virtuels. »

Qu'en est-il des hôpitaux « aux normes internationales » alors que les centres hospitaliers existants se caractérisent par un sous-équipement manifeste sans parler de la formation universitaire dans ce domaine ? Ainsi dans la ville de Toamasina, une filière de médecine a été ouverte au sein de l'université mais sans grands moyens (locaux, bibliothèques, enseignants). La construction d'un hôpital dans la ville de Mahajanga, où il existe déjà deux hôpitaux – certes dans un état qui laisse à désirer – interpelle. N'est-on pas dans un contexte plus prosaïque de passation opaque de marchés publics comme il en est de tous les chantiers publics mis en route dans ce même ordre d'idée ? Sans oublier l'assouvissement d'une vengeance personnelle car l'hôpital en question a été construit sur un terrain occupé par l'entreprise Magro appartenant au président renversé.

Dans le domaine agricole, la faim de terres est-elle le problème de la paysannerie malgache en général et celle des riziculteurs en particulier, alors que seulement 10 % des surfaces cultivables sont utilisées ? La distribution de terres, présentée comme le bon sens paysan participera-t-elle à l'augmentation de la production de riz ? Où s'agit-il d'une simple mesure inspirée par le populisme ?

Pourtant parmi les chantiers devrait figurer la démilitarisation du pouvoir, un tabou. De tous les régimes confondus, en trois ans, le régime de Rajoelina a été celui qui a nommé le plus de généraux, toute proportion gardée (Ramasy 2010, Yann 2010). Les militaires sont si puissants que des sous-officiers refusent de payer les impôts sur les différentes augmentations dont ils ont bénéficié depuis le début de la transition. L'on ne peut que s'interroger sur l'avenir de la démocratie ainsi que sur le développement durable quand on pense que les déboires du Mali et sans doute d'autres pays comme le Niger sont dus en grande partie à cette faiblesse de la démilitarisation du pouvoir (Ramasy 2010).

Le financement de ces grands chantiers dits de développement donne aussi une idée de ce que pourrait être la conception de ce dernier par ceux qui sont arrivés au pouvoir par un coup de force. « ...Nous avons octroyé les gisements de fer de Soalala à Wisco, une société chinoise. L'avance qu'ils nous ont consentie – d'un montant de plus de 100 millions de $US – a été allouée à la construction de centres hospitaliers dans les grandes villes. Nous sommes en train de construire des logements sociaux, des salles omnisports, des centres d'exposition et des salles de théâtre. Rien qu'avec les 100 millions de $US de la société Wisco, voyez ce que nous avons pu réaliser en termes d'infrastructures que nous laisserons à la postérité. Le volume des taxes minières devrait nous permettre de construire chaque année des hôpitaux, des écoles » (Razafimandimby 2011). Le point commun entre ce genre de pratiques et la gestion scandaleuse de la coupe du bois de rose est l'investissement des bénéfices tirés de la vente de matières premières dans l'équipement social et le fonctionnement de l'État. C'est le schéma classique d'une économie extravertie avec une croissance fictive qui ne profite que peu à l'économie réelle et a fortiori à l'ensemble de la population. Seulement c'est là gâcher un capital limité, sans espoir de bénéfice à long terme. L'épuisement des ressources naturelles et le sacrifice de plusieurs générations du fait de la déscolarisation ne sont pas sources de développement. Pas plus qu'un État qui entretient un esprit de rentier.

MANGER LE CAPITAL

Dans cette configuration, la survie miraculeuse de l'appareil d'État malgache repose essentiellement sur une économie de prédation qui est en train, non pas de produire des richesses mais plutôt de dilapider le capital environnemental et surtout humain de la population malgache. C'est un état de fait que nous allons payer plus que chèrement dans un avenir proche, quelle que soit la sortie envisagée.

Capital environnemental : « Reconnaissons le laxisme dans la gestion des richesses naturelles qui sortent du territoire sans contrôle. Si nous arrivons à baliser les 'exportations' de nos ressources minières : or, pierres précieuses... nous pourrions déjà améliorer la trésorerie de l'État » (Razafimandimby 2011).

Le scandale du bois de rose exporté à bas prix par une mafia organisée et ayant des ramifications jusqu'au plus haut sommet de l'État n'est que la partie visible de cette dilapidation du capital environnemental. À celui-ci il faut ajouter celui de minerais dont l'exploitation se fait dans la discrétion et souvent selon les mêmes mécanismes. Ces 'affaires' relèvent d'un artisanat de la prédation face à ce qui est mis en œuvre en toute opacité par des compagnies ayant pignon sur rue. Les médias officiels se taisent sur des mouvements paysans contre les géants qui s'occupent de l'exploitation de ces minerais et dont ils ne voient guère les dividendes. Pourtant il est de notoriété publique que les élites politiques et économiques sont partie prenante dans cette prédation qui affecte les revenus, voire la santé des populations locales.

Il est difficile d'en vouloir aux compagnies d'exploitation minière quand les gouvernants malgaches sont partie prenante, car inefficaces sinon complices, dans cette mise sous coupe réglée du capital environnemental.

Sur son site Internet,[4] le groupe Sherritt ou Ambatovy met l'accent sur son engagement à se livrer à « une pratique commerciale durable, responsable et transparente… avec le gouvernement malgache (par l'intermédiaire d') un contrat de bail à long terme. Pour quelque 150 millions de dollars améri-cains, et pour un minimum de 29 ans. » Ambatovy s'est arrogé les droits d'extraction minière dans une zone de forêt montagneuse située près de Moramanga. Durant cette période, la société compte extraire 60 000 tonnes de nickel, 5 600 tonnes de cobalt, et 210 000 tonnes de sulfate. Les prix sur le marché mondial de ces minerais utilisés dans la production d'acier inoxydable, les batteries et les engrais, ont fortement augmenté ces dernières années. À Madagascar, ces minerais sont seulement à trois mètres sous terre. Près de 98 % de la production sera exportée à l'étranger et seulement 2 % restera sur l'île. Il est probable que d'autres trésors soient stockés dans le sol.

À court terme, l'envolée des cours des matières premières est une aubaine pour un pays en développement comme Madagascar. C'est le temps sur lequel la politique se gère. Cependant, à plus long terme voire à moyen terme, cette dépendance à l'égard de produits à faible valeur ajoutée est problématique. Économistes et experts politiques ont depuis longtemps souligné les effets pervers induits par ces mannes soudaines. Dans de nombreux pays, elles rendent fictive la croissance économique, elles augmentent les risques de conflits, de guerre civile et de dérive anti-démocratique. Les divisions sociales ainsi accentuées affaiblissent les institutions, car accroissent la pauvreté, les inégalités, la corruption et dégradent les taux de l'épargne et le niveau, déjà faible, de la recherche et du développement (Havro et Santiso 2008a). Ses effets sur l'économie s'exercent au départ sous la forme du 'mal hollandais' puis par une éviction des secteurs indépendants des matières premières (Corden et Neary 1982).

L'autre effet pervers des mannes minières se trouve dans le changement des motivations des acteurs politiques et économiques. En effet, elles multiplient les opportunités de rentes économiques et attisent en conséquence les rivalités tout en décourageant les activités productives. Le Groupe des Entrepreneurs de Madagascar (GEM) rappelle dans son communiqué du 20 avril 2011, « la multiplication des cas de corruption et le racket organisé à tous les niveaux inhibent encore plus le secteur formel et favorisent la prolifération du secteur informel. » Le GEM dénonce entre autres « l'utilisation des organismes publics et des sociétés d'État à des fins autres que leur vocation statutaire. » Ceci est « contraire à la bonne gouvernance et illustre davantage la dégradation du climat des affaires. Le partenariat public privé y sert le plus souvent d'alibi. »

On ne peut pas assurer que les acteurs politiques et économiques qui se livrent à de telles pratiques puissent, dans un avenir proche, changer. Et ce d'autant plus que les sommes en circulation vont changer d'échelle ! Et nous ne sommes là que dans la phase où il est question de relancer l'économie.

Les projets en cours de réalisation du gouvernement de transition n'augurent rien de bon. Le pouvoir de facto qui se voit déjà au delà de la transition, gage sur les rentrées des rentes minières (Wisco, Sherritt, etc.). Celles ci sont appelées à concourir à la popularité à court terme du gouvernement et à renforcer son pouvoir, alors qu'elles sont porteuses de risques à moyen et à long termes plus nuisibles. Nous sommes dans le cas très classique de la « malédiction des matières premières » de Havro et Santiso (2008b). La composition des forces qui ont pris le pouvoir ne permet pas de penser que dans un avenir proche et même à moyen terme, le populisme et la recherche de rentes vont laisser la place à une politique économique allant dans le sens du développement durable se basant sur les forces vives du pays.

Les constats du GEM montrent que le gouvernement fait fi des secteurs non miniers pour éviter le syndrome hollandais et la perte d'emplois dans les autres secteurs (360 000 depuis le coup d'État selon cette organisation). La destruction irrémédiable sans contrepartie durable de l'environnement est l'autre conséquence de cette course irréfléchie aux matières premières. Elle n'est pas sans conséquence sur la santé et les modes de vie des locaux.

Il n'est de ressources que les ressources humaines, tous les 'dragons asiatiques' ont investi massivement dans les formations universitaires et scolaires, base de leur réussite. C'est un travail de longue haleine à l'opposé du clinquant qui relève plus de la psychanalyse.

DILAPIDATION DU CAPITAL HUMAIN

« Le taux de l'exclusion scolaire a augmenté depuis la crise politique dans le pays. Actuellement, plus d'un million d'enfants au niveau primaire sont non-scolarisés. En fait, le taux net de scolarisation au primaire n'est plus que 73,4 % en 2010 contre 83,3 % en 2005. Pour l'année 2010, près de 700 000 enfants de 6 à 12 ans ont quitté le système scolaire entre le Cp 1 et le Cm1 » (V. 2012). Ces chiffres semblent en deçà de la réalité puisque d'autres sources parlent de « la pauvreté (qui) pousse deux millions d'enfants dans le travail forcé » (Saholiarisoa 2009).

Cette exclusion scolaire porte gravement atteinte aux efforts fournis antérieurement du fait du déni de l'existant et de la recherche de popularité à bas prix. L'exclusion scolaire au cycle primaire est un facteur très négatif pour le développement. Rappelons que le taux de scolarisation d'enfants inscrits dans l'enseignement primaire est passé de 82 % à 100 %, entre 1997 et 2007 (Ministère de l'Éducation Nationale et de la Recherche Scientifique 2008, p 55). Parallèlement, le pourcentage de redoublants a reculé passant de 30 % en 2000 à 18 % en 2006. Ces progrès ont été notamment obtenus grâce à la mise à contribution de l'association des parents d'élèves ou Fram. Celle-ci a permis l'augmentation de 50 % du nombre d'enseignants non fonctionnaires. Le ratio élèves par enseignant était passé de 60 à 52 dans les écoles publiques. La crise économique induite par le coup d'État a appauvri les familles et obéré ce système. Que dire des efforts à fournir à propos de l'enseignement secondaire ? L'accès à l'enseignement secondaire du premier cycle (collège) est très faible, Madagascar fait partie des pays de l'Afrique Subsaharienne qui ont les plus faibles taux de scolarisation pour l'enseignement secondaire. Le sort fait aux enseignants ne diffère pas de celui de leurs collègues du primaire. À l'heure où cette étude est écrite, une grève affecte l'ensemble des établissements de l'île à des degrés divers.

Dans cette pyramide du système éducatif, l'enseignement supérieur n'est pas le mieux loti. Ainsi le marasme ancien de l'enseignement supérieur est vu comme résultant du choix de formations inadéquates. Il n'est nullement fait allusion à l'état de délabrement général dans lequel, en particulier, 25 ans de socialisme démagogique l'ont laissé. Depuis plusieurs décennies, le budget alloué à l'enseignement supérieur va pour l'essentiel dans les œuvres sociales, transformant les Universités en lieu de parcage de la frange de la jeunesse qui a pourtant réussi à survivre à la sélection dans les niveaux inférieurs. Très peu est consacré à l'enseignement proprement dit et encore moins à la recherche. Il est incapable non seulement d'absorber mais aussi de former de manière satisfaisante des générations de plus en plus importantes de bacheliers. Faute d'enseignants d'abord ; faute d'infrastructure ensuite. Il n'est pas fait allusion aux reformes mises en stand by par 'la transition'.

La réponse des autorités de facto en ce qui concerne l'enseignement supérieur est, pour le moment, la construction de cités universitaires. Ainsi à l'Université de Tamatave, tous les locaux d'enseignement sont délabrés. Conçus initialement pour 700 étudiants, il y plus de 30 ans, ils n'ont connu que quelques aménagements mineurs comme la transformation des locaux du restaurant universitaire en salles de cours. En constante augmentation, le nombre d'étudiants s'élève actuellement à plus de 7 000. Une cinquantaine d'enseignants permanents pour 7 000 étudiants fait que les premiers croulent sous les heures de cours, sacrifiant la recherche. Pour toute réponse, les autorités de transition ont construit une cité universitaire d'une capacité de 300 places au grand maximum. Elles ont aussi ouvert une filière de philosophie dans la ville d'Ambatondrazaka, l'un des greniers à riz de la Grande Île ! C'est un recul de plusieurs années qui nous ramène à l'ère socialiste, plus soucieuse de statistiques que de résultats.

Toute discipline confondue, les 1 000 enseignants chercheurs sont entrés en grève à plusieurs reprises pour réclamer une indemnité de recherche prévue par les textes. Le ministre du budget s'est plaint que ces grèves aient fait perdre 15 milliards à l'État. Que dire d'une gouvernance qui considère les jeunes et leurs formateurs plus comme des obstacles que comme des atouts ?

Les conditions d'études déplorables et la faiblesse de l'encadrement sont à la base de la dérive de l'enseignement universitaire. Elles font les choux gras de la presse à sensation. À Toamasina, un film pornographique circule sous le manteau ; il a été tourné dans la cité universitaire. Un étudiant a été arrêté pour avoir tenté de vendre plus de 15 litres d'huile de cannabis, sans parler d'une prostitution institutionnalisée puisque les cadres de la société Sheritt se fournissent chez les étudiantes (témoignage personnel). Le summum fut atteint avec l'arrestation sous des prétextes fallacieux de Raymond Ranjeva, un des grands intellectuels malgaches et de sa fille.

Cette dilapidation du capital humain va de pair avec l'effondrement des valeurs sur lesquelles la société malgache est érigée sans que se profile à l'horizon le moindre signe ni espoir d'une reprise en main. Les pessimistes diront que le pire est à venir.

CONCLUSION

L'un des enjeux des conflits politiques actuels à Madagascar est la manne minière arrivant dans les mois qui viennent. Le paradoxe de l'abondance peut faire croire à un ego mal placé qu'il est au centre d'une abondance dont il n'est pas à l'origine. Il semble, dans la logique autocratique, tenté d'investir dans le clinquant en comptant uniquement sur des ressources qui ne sont pas infinies alors qu'une économie diversifiée mobiliserait les véritables forces vives de la nation.

Apparemment, bien avant qu'il ne réussisse à s'institutionnaliser, le régime d'Andry Rajoelina s'est engagé vers ce que lui-même ne cessait de dénoncer et d'attribuer à son prédécesseur. « Aucun contre-pouvoir au régime présidentiel n'a pu empêcher les régimes qui se sont succédés de dériver vers le népotisme, la corruption généralisée et la prédation des fonds publics. Avec cette nouvelle constitution, le président ne pourra plus mettre l'économie du pays au service de ses intérêts personnels ; il ne pourra plus, non plus, transformer son pouvoir en un pouvoir autocratique. »

La croyance qu'un texte constitutionnel puisse changer des pratiques qui se sont multipliées pendant les trois ans de la 'transition', relève de la naïveté ou du machiavélisme. Cette dernière apparaît comme une transition vers plus de corruption et de népotisme. Et le maître de céans semble se leurrer, perdu dans ses illusions. « Je ne suis pas arrivé seul à la tête de l'État. Ce sont les citoyens malgaches, avec le soutien d'une grande partie des élus et des militaires, qui ont contraint le dictateur au départ. C'est ce vaste mouvement populaire qui m'a porté » (Chauprade 2010). « Il me réjouit de constater, lors de mes pérégrinations à travers l'île, que l'élan populaire est en hausse. C'est ce que je perçois sur le visage des gens. Leurs traits expriment cette sympathie et je vois dans leur regard un regain de confiance et de conviction. Ce constat me va droit au cœur » (Razafimandimby 2011).

Love me tender

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NOTES

1 L'ONG AKamasoa (« les bons amis ») s'est développée de manière exponentielle depuis 2009. L'association humanitaire créée par le Père Pedro OPEKA en 1989, selon son site, a dans les environs d'Antananarivo 5 centres d'accueil composés de 17 villages où se sont installées 2926 familles (15 560 personnes dont plus de 60 % d'enfants de moins de 15 ans). Elle se vante d'entretenir 1 lycée et 5 crèches <http://www.pere-pedro.net/akamasoa.html> Pourtant des six provinces,

celle d'Antananarivo est celle dont le taux de pauvreté est le moins élevé.

[2] Lors de la constitution des institutions qui remplacent l'Assemblée nationale et le Sénat, pompeusement qualifiées de Conseil Supérieur de la Transition et de Conseil de la Transition, plusieurs témoins parlent de la nomination des nombreux membres contre de l'argent (Tribune 2 décembre 2011)

[3] Monja Roindefo qui a conduit l'assaut du palais présidentiel à la tête des partisans d'Andry Rajoelina témoigne de l'existence des manœuvres destinées à créer des martyrs (dont lui-même) pour diaboliser Ravalomanana. Celles ci consistaient entre autres à tirer sur la foule <http://ampitapitao.blogspot.com/2012/02/monja-roindefo-il-y-eu-des-tirs-croises.html>

[4] <http://www.ambatovy.com/docs/?post=17&lang=fr>

SUPPLEMENTARY MATERIAL.

DISPONIBLE EN LIGNE UNIQUEMENT.

TABLEAU S1. Évolution du ratio de pauvreté de 1993 à 2010.

TABLEAU S2. Évolution des indicateurs de gouvernance (élaboré par Ndimby Andrianavalona; *indique le score idéale).

ARTICLE

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Suivi du Gecko *Phelsuma serraticauda* (Squamata : Gekkonidae) dans la région Atsinanana, dans l'est de Madagascar

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RÉSUMÉ

Cette étude a été effectuée sur le Gecko *Phelsuma serraticauda* durant les mois d'octobre et décembre 2008 dans 57 sites dans l'est et nord-est de Madagascar. Elle a pour objectifs de déterminer l'aire de distribution dans l'est de Madagascar et l'utilisation d'habitat de cette espèce pour sa conservation et son utilisation durable. La plupart des observations des individus sur les plantes sont sur le cocotier *Cocos nucifera* (84,3 %) et le fruit de pain *Artocarpus altilis* (4,9 %), avec 8,3 % sur le mur d'une maison en bois. Le nombre de *P. serraticauda* varie entre un et cinq par biotope avec une moyenne de 2,6 ± 0,2 pour l'ensemble des plantes et de 1,7 ± 0,4 pour les maisons. Parmi les 29 pieds de cocotier, 34 % sont occupés chacun par un seul individu mâle ou femelle, 14 % par deux femelles, 10 % par deux mâles, 10 % par un mâle et une femelle, et 10 % par deux mâles et une femelle. Le nombre moyen de mâle a été 1,06 ± 0,20 et 1,00 ± 0,15 pour la femelle. Sur les quatre maisons visitées, trois sont occupées chacune par une femelle et la dernière par trois mâles et deux femelles. Le nombre moyen de mâles a été 0,75 ± 0,75 et de 1,25 ± 0,25 pour les femelles. *Phelsuma serraticauda* est rarement trouvé sur des eucalyptus, *Artocarpus heterophylllus* et autres palmiers. Cette espèce n'est pas recensée dans la forêt humide de basse altitude d'Analalava, à la périphérie de la forêt littorale d'Antetezana et dans la plantation de *Ravenala madagascariensis*. L'analyse des matières fécales a montré que l'espèce se nourrit principalement d'araignées, coléoptères, hyménoptères, hémiptères et de leurs larves. Elle est sympatrique avec *P. lineata* et *P. quadriocellata*. La collecte de *P. serraticauda* dans la nature est allouée avec une autorisation légale et suivant le quota fixé par la CITES. Des cas de collecte illicite qui constitue une menace pour l'espèce de *P. serraticauda*, sont notés pendant cette étude. Compte tenu de l'état actuel des populations de *P. serraticauda* et de l'absence de mesures de conservation, un système de monitoring et un site de conservation pour cette espèce devraient être mis en place de toute urgence. Cette étude est la première réalisée sur cette espèce dans son état sauvage pour mieux comprendre ses besoins en termes d'habitat et les mesures de conservation à long terme de l'espèce.

ABSTRACT

The diurnal gecko *Phelsuma serraticauda* has a restricted range in eastern and northeastern Madagascar. A study was undertaken in 57 sites mostly in Ivoloina and its surroundings areas in October (phase 1) and December (phase 2) 2008. The main objectives were to elucidate the distribution area in the east of Madagascar and to determine the habitat use of *P. serraticauda* to help ensure its conservation and sustainable use. Most of the observations on plants were from coconut tree *Cocos nucifera* (84.3 %) and breadfruit *Artocarpus altilis* (Moraceae, 4.9 %), with 8.3 % from houses. The number of *P. serraticauda* per biotope varied between one and five with means of 2.6 ± 0.2 for all plants and 1.7 ± 0.4 for the houses. Among the 29 coconut trees, 34 % were each occupied by one male or female, 14 % by two females, 10 % by two males, 10 % by one male and one female, 10 % by two males and one female. The mean number of male of *P. serraticauda* on the coconut trees was 1.06 ± 0.20 and 1.00 ± 0.15 for female. Among the four analysed houses, three were occupied by one female and one by three males and two females. The mean number of male *P. serraticauda* on the houses was 0.75 ± 0.75 and 1.25 ± 0.25 for female. *Phelsuma serraticauda* was also found infrequently on *Eucalyptus* sp., *Artocarpus heterophyllus*, and other palm trees such as *Dypsis* sp. This species of gecko was not recorded in the humid forest of Analalava, in the edge of the Antetezana littoral forest, and in the vast plantation of *Ravenala madagascariensis* situated in the surrounding-areas of Ivoloina. Results from faecal analysis showed that *P. serraticauda* prey mostly on spiders, coleopterans and hymenopterans, hemipterans and their larvae. *Phelsuma serraticauda* was found sympatrically with *P. lineata* and *P. quadriocellata*. The collection of this species in the wild is allowed with legal authorization and with respect to the quotas fixed by CITES. We have noted cases of illegal collection of *P. serraticauda* during this study. The trade constitutes a threat for this gecko. Its populations are fragmented and are also threatened by habitat loss. Bearing in mind the lack of current conservation measures and the present state of the populations of *P. serraticauda*, a monitoring system and a conservation site for this species should be urgently established. This study is the

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first on this species in the wild and constitutes the beginning of many studies needed to better understand its habitat requirements and to ensure the long term survival of the species.

INTRODUCTION

Madagascar, par sa richesse en flore et faune endémique, est placé parmi les pays prioritaires à la conservation de la biodiversité dans le monde (Vences et al. 2009). Plusieurs taxons sont caractérisés par un taux élevé de microendémicité dans la grande île (Wilmé et al. 2006). Les reptiles à Madagascar présentent plus de 363 espèces décrites avec un taux d'endémicité de 92 % (Glaw and Vences 2007).

Les geckos diurnes du genre *Phelsuma* Gray composés par 43 espèces décrites dans le monde (Rocha et al. 2009), ont une large distribution dans les îles de l'ouest de l'Océan Indien (Nussbaum et al. 2000). Madagascar est connu comme étant le centre de la diversité de *Phelsuma* (Raxworthy and Nussbaum 1994) avec 30 espèces dont 26 endémiques (Crottini et al. 2011). Six nouvelles espèces ont été décrites ou revalidées depuis 2009 (ex. Glaw et al. 2009, Crottini et al. 2011).

Parmi les espèces de *Phelsuma* existant à Madagascar, 15 sont menacées dans la Liste Rouge de l'UICN (IUCN 2011). *Phelsuma serraticauda* est l'une des espèces classée 'En danger' dans cette Liste Rouge de l'UICN (Randrianantoandro et al. 2011). Elle est aussi classée dans l'Annexe II de la CITES. Selon la législation nationale malgache, elle est dans la catégorie I, classe II du classement des espèces de faune sauvage selon le décret 2006-400 du 13 juin 2006, allouant sa collecte pour l'exportation mais avec présentation d'une autorisation et selon le quota annuel fixé par CITES. Cependant, depuis janvier 1995, le commerce de cette espèce est suspendu et l'exportation des animaux vivants de cette espèce provenant de Madagascar pour le commerce est interdite.

L'espèce *P. serraticauda* est localisée dans le centre-est de Madagascar et dans une région limitée dans la côte nord-est de Madagascar (Raxworthy & Nussbaum 1993). La connaissance historique sur les aires de distribution de *P. serraticauda* dans cette région est Manompana et Mananara (Gehring et al. 2010). Cette espèce pourrait être aussi présente à Masoala et Antalaha (Raxworthy, comm. pers.), mais cette information nécessite confirmation. La localité type de *P. serraticauda* est Ivoloina (Raxworthy & Nussbaum 1993, Glaw & Vences, 2007). Cette étude est menée dans le but de déterminer les aires de distribution au sein et aux alentours de sa localité type et l'utilisation de l'habitat par *P. serraticauda*, pour la conservation et la gestion durable de cette espèce.

MATÉRIELS ET MÉTHODES

L'étude est effectuée principalement à Ivoloina et ses environs, district Toamasina II, région Atsinanana, Est de Madagascar (Figure 1). Elle s'est déroulée en deux phases : du 30 septembre au 08 octobre et du 06 au 13 décembre 2008. Les sites ont été choisis par leur emplacement (sud, nord, est et ouest) avec Ivoloina au centre et par les caractéristiques de l'habitat (forêts humide ou littorale, anthropogénique avec *Cocos nucifera* ou *Ravenala madagascariensis*). Au total, 57 sites sont visités, dont 35 pendant la première et 22 pendant la seconde phase. Ils sont localisés entre les latitudes S18° 52′ 40,3″ et 17° 42′ 32,6″ et les longitudes E49° 28′ 11,7″ et 49° 20′ 34,9″. Dans chaque site, les geckos *Phelsuma* ont été recherchés dans tous les types de végétation : palmier, bambous, arbres, ainsi que les murs et les toits des maisons fabriquées principalement avec du bois et *Ravenala*. L'observation est effectuée pendant le jour, à partir de 08:00 jusqu'à 17:00. Lorsqu'un animal est détecté, l'espèce est déterminée en utilisant le guide sur les reptiles et amphibiens par Glaw & Vences (2007). Après, il est capturé à la main ou à l'aide d'une ficelle pour la détermination du sexe et de l'âge principal (adulte ou juvénile). Les mâles sont faciles à identifier grâce à la présence des pores fémoraux et de l'hémi-pénis dans la partie bombée à la base de leur queue (Glaw & Vences 2007). La longueur du museau-cloaque (LMC) et le poids de l'animal sont ensuite mesurés à l'aide d'un pied à coulisse (avec une précision de 0,1 mm) et d'une balance de précision (avec une précision de 0,1 g). Le nom et la caractéristique de chaque plante : fertile ou non (déterminée par la présence ou non des fleurs et/ou des fruits) sont notés.

Pour déterminer les caractéristiques des cocotiers utilisés par *P. serraticauda*, une placette de 50 m x 50 m a été placée dans un site à Analamboanio où 20 cocotiers *Cocos nucifera* (Arecaceae), 2 bananiers *Musa* sp. (Musaceae), 1 manguier *Mangifera indica* (Anacardiaceae) et une maison en bois, sont observés. La hauteur et le diamètre à hauteur de poitrine (ou dhp) des arbres sont mesurés à l'aide d'une tige graduée d'une hauteur de 3 m et d'un mètre de dhp. Le pied de cocotier est considéré fertile s'il présente une floraison ou fructification et non-fertile si aucune de ces caractéristiques n'est observée. Chaque pied est observé successivement pendant une durée moyenne de 20 minutes. Le nombre des individus de *P. serrati-*

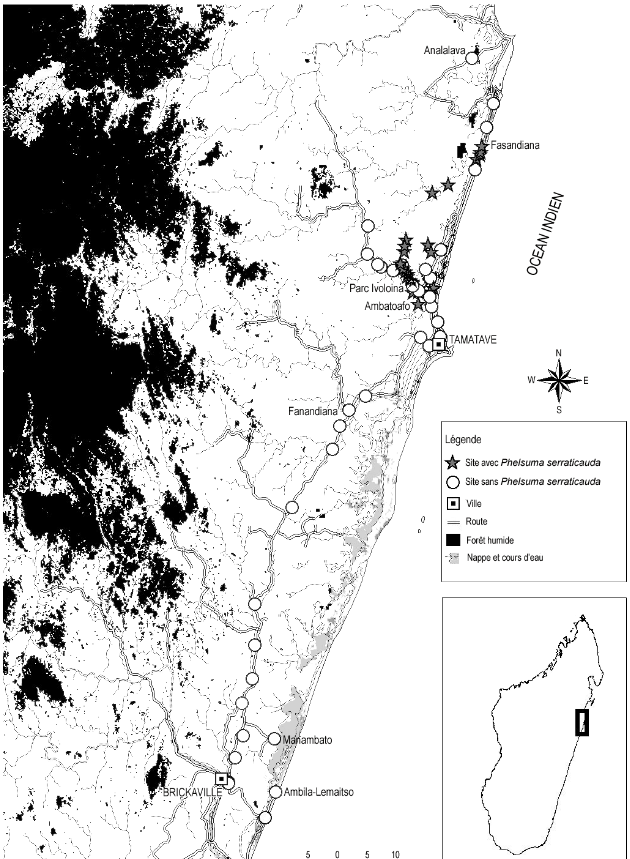

FIGURE 1. Carte montrant les sites sans *Phelsuma serraticauda* (en rond) et avec *P. serraticauda* (en étoile grise) visités pendant le mois d'octobre et décembre 2008.

cauda et des autres espèces de gecko sur chaque pied est noté. Chaque animal est capturé, puis marqué à l'aide d'une petite quantité de correcteur fluide pour déterminer s'il y a changement de biotope ou non. Chaque marquage correspond à un code qui est spécifique à chaque biotope sur lequel le gecko est recensé.

Les animaux capturés sont gardés provisoirement dans des pochons. L'alimentation des geckos est étudiée à partir des matières fécales déposées par l'animal dans ces pochons. Les résidus des invertébrés sont séparés l'un de l'autre à l'aide d'un microscope au laboratoire et suivant les méthodes décrites dans Hofer et al. (2003). Le pourcentage de fréquence des proies, après avoir été classées par Ordre, est calculé à partir de la présence ou absence de chaque classe (Ordre) dans les 13 matières fécales collectées.

Pour les nouveaux sites de *P. serraticauda*, une photo de l'individu est prise pour enregistrer la coloration originelle de l'animal et un spécimen de référence est collecté et déposé dans la salle de collection du Département de Biologie Animale de l'Université d'Antananarivo. Pour se faire, l'animal est fixé avec du formol (10 %) et est ensuite préservé dans une solution d'éthanol à 70 % après rinçage massive avec l'eau. Les données suivantes sont notées pour chaque spécimen : la date, l'heure, les coordonnées géographiques par des GPS (Garmin etrex et 60 Csx), l'altitude par l'altimètre (Venture Oregon scientific), le type de microhabitat, la position de l'animal et les espèces sympatriques.

Les analyses statistiques sont faites avec le logiciel Stat-View (SAS, 1998). ANOVA est utilisée pour tester la différence entre les longueurs du museau-cloaque et les poids des mâles et femelles des deux phases d'étude. Le test non-paramétrique Mann-Whitney est utilisé pour comparer le nombre des individus observés sur les arbres fruitiers fertiles et non fertiles. La relation entre le nombre d'individus observés avec la hauteur des arbres et le diamètre à hauteur de poitrine (dhp) est déterminée par la Corrélation de Spearman. Le niveau d'évidence statistique est fixé à $P = 0,05$ (Zar, 1984).

Des enquêtes sont réalisées auprès des chasseurs, des collecteurs, des marchands et des villageois pour collecter des informations supplémentaires sur l'espèce. Au total, 19 personnes ont été interrogées pendant cette étude.

RÉSULTATS

Au total, 208 individus de *P. serraticauda* (Figure 2) ont été observés, dont 135 pendant la première phase et 73 durant la seconde phase. La liste des spécimens collectés et la localisation des sites de collecte respectifs sont présentées dans le Tableau 1. Nous avons recensé trois espèces sympatriques *P. lineata* (23 individus pendant la première phase et 19 pendant la seconde phase), *P. parva* (7 individus pendant la première phase et 16 pendant la seconde phase), et *P. madagascariensis* (4 individus pendant la première phase et 24 pendant la seconde phase).

STRUCTURE DE LA POPULATION. L'ensemble de la population observée est composé principalement (87 %) par des adultes. Les jeunes éclos sont recensés pendant le mois de décembre. La longueur du museau-cloaque et le poids des femelles adultes sont significativement différents entre les deux phases ($F_{1,32} = 14,142$; $P = 0,0007$ et $F_{1,31} = 6,467$; $P = 0,01$), mais la différence n'est pas significative pour les mâles (Tableau 2).

FIGURE 2. Gecko diurne *Phelsuma serraticauda* sur un pilier d'une maison en bois à Analamboanio dans le quartier d'Ambonivato.

UTILISATION DE L'HABITAT. Le gecko *P. serraticauda* est observé sur différentes espèces d'arbres non-autochtones et de structures fabriquées. La plupart des observations sur les plantes sont sur le cocotier *Cocos nucifera* (84,3 %), suivi par le fruit de pain *Artocarpus altilis* (Moraceae, 4,9 %), le jacquier *Artocarpus heterophyllus* (Moraceae, 1 %), le palmier *Dypsis* sp. (Arecaceae, 1 %), ainsi que sur l'*Eucalyptus* sp. (Myrtaceae, 0,5%), avec 8,3% sur le mur ou le pilier d'une maison en bois. Le nombre moyen (± ES) de *P. serraticauda*, par biotope varie entre 1,0 ± 0 et 5,0 ± 4,0, et n'est pas similaire pour l'ensemble des plantes (2,6 ± 0,2) et de structures fabriquées (1,7 ± 0,4) (Figure 3).

Le nombre moyen d'individus observés sur les cocotiers fertiles est 2,76 ± 0,33 contre 1,5 ± 0,5 sur les cocotiers non-fertiles, mais la différence n'est pas significative (Mann-Whitney, $U = 55,5$ et $P = 0,279$). En outre, le nombre d'individus observés n'est pas significativement corrélé avec la hauteur de la plante ($r = 0,217$; $P = 0,261$) ou le diamètre à hauteur de poitrine des arbres ($r = 0,206$; $P = 0,145$). La hauteur de la plante occupée par *P. serraticauda* varie entre 1 m et 13 m et le dhp des arbres se situe entre 12 cm et 38 cm.

Le résultat du marquage montre qu'un changement de biotope par l'animal est noté. Une femelle adulte, marquée l'après midi sur un cocotier, est observée le matin sur la maison en *Ravenala madagascariensis* (Strelitziaceae). La distance entre ces deux biotopes est de 10 m. Des observations faites pendant le jour ont montré que l'espèce a aussi fréquenté le bananier. Aucun individu n'est observé se déplaçant sur le sol, l'espèce utilise les parties des plantes et des structures élevées pour passer d'un biotope à un autre.

TABLEAU 1. Liste des spécimens collectés et localisation de leurs sites de collectes.

Espèce	Numéro UADBA	Site	Coordonnées géographiques	Elevation (m)
Phelsuma serraticauda	49456	Ambalafary	E49º 23' 29,1'' S18º 00' 20,6''	75
Phelsuma serraticauda	49488	Sahankiko	E49º 24' 56,2'' S17º 54' 12,0''	17
Phelsuma serraticauda	49560	Sahabefoza	E49º 21' 48,1'' S18º 04' 06,5''	7
Phelsuma serraticauda	49554	Ankadirano	E49º 28' 07,5'' S17º 51' 05,1''	17
Phelsuma serraticauda	49495	Ambodimanga	E49º 27' 41,3'' S17º 51' 43,9''	19
Phelsuma serraticauda	49496	Ambatoafo	E49º 22' 21,9'' S18º 05' 09,4''	45
Phelsuma serraticauda	49581	Analamboanio	E49º 23' 34,2'' S17º 54' 53,0''	24
Phelsuma serraticauda	49497	Marotandrazana	E49º 21' 06,0'' S17º 59' 16,0''	8
Phelsuma serraticauda	49528	Saraimbolo	E49º 20' 49,6'' S18º 01' 53,8''	36
Phelsuma serraticauda	49503	Ambodinonoka	E49º 20' 56,0'' S18º 00' 20,0''	65
Phelsuma serraticauda	49470	Vohilava	E49º 20' 34,9'' S18º 01' 28,7''	28
Phelsuma serraticauda	49485	Fasandiana	E49º 28' 11,7'' S17º 50' 31,8''	24

ZONE D'OCCURRENCE. *Phelsuma serraticauda* est recensée dans 23 des 57 sites visités. Elle n'est pas observée au sud d'Ambatoafo (2 km environ au sud d'Ivoloina) et au nord de Fasandiana même si l'habitat adéquat existe dans ces régions (Figure 1). Cette espèce se trouve entre 3 m et 75 m d'altitude et n'est pas recensée dans la forêt humide de basse altitude d'Analalava présentant une altitude allant jusqu'à 79 m. Parmi les 23 sites visités où *P. serraticauda* est recensée, 59,25 % ont une topographie plate et 29,62 % se présentent sous forme d'une petite colline. Les milieux montrant une pente assez marquée ou se présentant sous forme d'une cuvette sont rarement occupés par l'animal.

ALIMENTATION. Au total, 13 matières fécales sont collectées. Leurs contenus sont groupés dans 6 catégories de proies. L'espèce *P. serraticauda* se nourrit principalement d'araignées dont le pourcentage de fréquence dans toutes les matières fécales collectées est 53 % (47 % ne renferment pas d'araignées). Des coléoptères (46 %), des hyménoptères (38 %), des hémiptères et larves (7 % chacun) sont aussi parmi ses proies. Celles qui constituent les 38 % restant ne sont pas identifiées.

TERRITORIALITÉ. Parmi les 29 pieds de cocotier, 34 % sont occupés par un seul individu (17 % par mâle et 17 % par une femelle), 14 % par deux femelles, 10 % par deux mâles, 10 % par un mâle et une femelle, 10 % par deux mâles et une femelle. Le nombre moyen (± ES) de mâle est de 1,06 ± 0,20 (avec un minimal et maximal de 0 à 5) et de 1,00 ± 0,15 (avec un minimal et maximal de 0 à 3) pour la femelle. Sur quatre maisons visitées, trois sont occupées par une seule femelle et la dernière par trois mâles et deux femelles.

COLLECTE. Les résultats des enquêtes auprès des 19 personnes ont montré que des cas de collectes de *P. serraticauda* sont notés depuis 1985 jusqu'en 2004 et un cas plus récent est rapporté dans 3 sites visités. En décembre 2008, des collectes sont signalées par les villageois d'Analamboanio entre les deux phases de la présente étude. Les autorités locales (Maire et Chef *fokontany*) ainsi que les concessionnaires des plantations de cocotier ont affirmé qu'ils n'ont pas été avisés et n'ont donné aucun avis favorable pour ces collectes. Le collecteur a trompé les résidants en leur disant qu'il devait donner des vitamines aux geckos. La fréquence des commandes était bi-annuelle et a connu son apogée en 1985 quand à peu près 1 000 individus ont été collectés dans les milieux sauvages (Randria et Rabemananjara, comm. pers.). Le nombre d'individus imposés par les collecteurs à chaque chasseur est entre 30 et 50 et les collecteurs ont acheté entre 100 à 200 individus adultes sans préférence sexuelle pour chaque descente. Les collecteurs ont généralement acheté auprès des chasseurs un individu de *P. serraticauda* entre 200 à 300 Ariary, ce qui équivaut à 0.10 et 0.14 US$, et occasionnellement 1 000 Ariary (0.48 US$).

Pendant cette étude, 4 œufs en éclosion sont observés dans la litière au niveau de l'axile des cocotiers ; ils se sont

TABLEAU 2. Valeurs moyennes (± ES), minimales et maximales (entre parenthèses en dessus) des variables morphologiques de *Phelsuma serraticauda* pendant les deux phases. Comparaisons par ANOVA des variables chez les mâles et femelles adultes entre phase 1 (du 01 au 08 octobre 2008) et phase 2 (du 06 au 14 décembre 2008).

	Sexe	Phase 1	Phase 2	F	P
Longueur Museau cloaque (mm)	Mâle	59,66 ± 2,26 (50,04 - 68,60)	54,35 ± 2,09 (40,74 - 67,60)	2,609	non significative
		(10)	(18)		
	Femelle	55,07 ± 1,66 (47 - 68,30)	48,76 ± 0,84 (40,99 - 56,80)	14,142	<0,001
		(11)	(23)		
Poids (g)	Mâle	6,05 ± 0,68 (3,4 - 9,1)	4,89 ± 0,45 (2,5 - 9)	2,083	non significative
		(10)	(18)		
	Femelle	4,40 ± 0,57 (2,5 - 9,7)	3,25 ± 0,14 (2 - 4,5)	6,467	<0,05
		(11)	(22)		

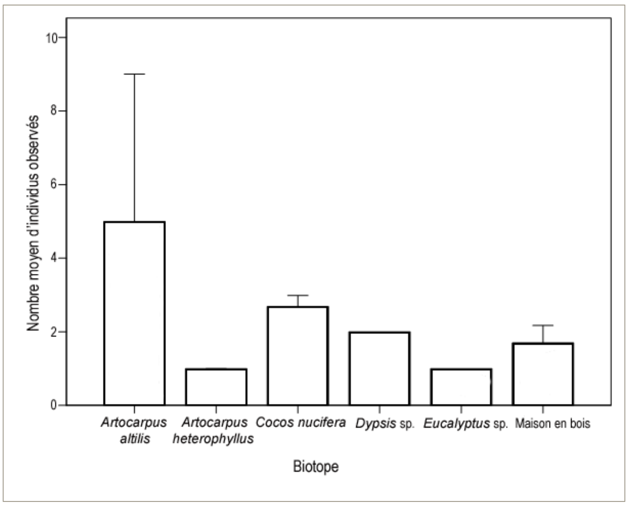

FIGURE 3. Nombre moyen (± ES) d'individus de *Phelsuma serraticauda* observés sur chaque biotope où l'espèce est recensée.

collés entre eux et aux substrats et pourraient appartenir à *P. serraticauda*.

Les prédateurs de *P. serraticauda* dans la région d'Ivoloina sont inconnus. Ils pourraient être constitués par *Acridotheres tristis*, *Falco newtoni* et *Felis catus*.

DISCUSSION

La présente étude a montré que *P. serraticauda* se trouve dans des nombreux sites à Ivoloina et ses environs. La limite de son aire de distribution au Sud est Ambatoafo alors que la limite au Nord a besoin de confirmation. Cependant, Wilmé et al. (2006) ont établi une carte montrant 12 centres d'endémisme pour Madagascar, dont le second séparé par la Baie d'Antongil correspond en grande partie avec la zone d'occurrence de *P. serraticauda* à l'exception de la grande partie Sud et Nord-Ouest. Cette espèce ne se trouve pas sur les plantes natives ou endémiques dans le sud de son aire de distribution. Notre observation effectuée à Tamatave n'a pas révélé la présence de *P. serraticauda* mais celle de *P. laticauda* qui pourrait être introduite dans ce site suite à des activités d'élevage en captivité. La plupart des sites avec *P. serraticauda*, présentant de l'habitat anthropogénique, se trouve dans le nord d'Ivoloina. La présence de cette espèce dans ce type d'habitat pourrait être aussi due à l'introduction. Du fait que l'espèce est connue à Manompana et Mananara, des recherches dans ces sites situés plus au nord pourraient élucider l'habitat originel de *P. serraticauda* qui est mal connu, étant donné que l'espèce n'est pas recensée dans la forêt humide d'Analalava, dans la périphérie de la forêt littorale d'Antetezana ainsi que dans la vaste plantation de *Ravenala madagascariensis* à Ivoloina pendant cette étude. La distribution actuelle de *P. serraticauda* est souvent le long de la côte où une topographie plate est notée et les plantes utilisées par l'espèce ne sont pas souvent natives. Une plante comme le cocotier est abondante dans ce milieu et peut être bien utilisée par *P. serraticauda* comme lieu de refuge. Outre cette liaison spécifique avec les plantes, l'espèce peut aussi coloniser l'habitat anthropogénique. Glaw & Vences (2007) ont mentionné que cette espèce fréquente aussi le bananier et ceci est conforme à l'observation faite durant le jour pendant cette étude. Pendant la nuit, l'espèce paraît se réfugier sur les cocotiers et le toit des maisons. Raxworthy & Nussbaum (1993) ont mentionné que plusieurs espèces de *Phelsuma* montrent un haut degré de spécialisation de l'habitat. Elles sont généralement connues comme étant arboricoles à l'exception des deux espèces *P. barbouri* et *P. malamakibo*, qui habitent sur les rochers (Glaw & Vences 2007). Les deux espèces endémiques du sud-est de Madagascar : *P. antanosy* vit sur *Ravenala madagascariensis* et *Pandanus* spp. (Raxworthy & Nussbaum 1993), et aussi sur les palmiers *Dypsis* spp. et pond des œufs sur *Pandanus* sp. (Jenkins et al. 2011) ; *Phelsuma malamakibo* vit et pond des œufs sur les rochers (Glaw & Vences 2007) ; et *P. ravenala* vit principalement sur le *Ravenala* (Raxworthy et al. 2007). Cet endroit semble être favorable pour l'incubation des œufs. L'autre lieu de ponte probable pour l'espèce est l'intérieur des feuilles de *R. madagascarensis* utilisées principalement pour la fabrication des toits de maison.

Du point de vue commerce, *P. serraticauda* est parmi les espèces recherchées par les exportateurs, dû probablement à sa coloration vive attirante et la forme spéciale de sa queue. Selon la législation nationale malgache, elle est parmi les espèces protégées mais peut donner lieu à la délivrance d'autorisation de chasse ou de capture, commerciale ou sportive dans les conditions réglementaires. La CITES a interdit, depuis 1995, l'exportation de toutes les espèces de *Phelsuma* y compris *P. serraticauda*, à l'exception *P. lineata*, *P. madagascariensis*, *P. laticauda* et *P. quadriocellata* (CITES Secretariat, 1995). Malgré cela, les collectes illicites existantes dans les localités aux environs d'Ivoloina pourraient avoir des conséquences néfastes sur la gestion et l'exploitation durable de l'espèce si aucune mesure n'est prise. Les bénéfices inéquitables entre les chasseurs, les collecteurs, et les exportateurs à propos de la vente des animaux sauvages, sont aussi un point à soulever à Madagascar où le commerce d'animaux ne contribue pas énormément à l'amélioration des conditions de vie des populations locales et environnantes.

CONSERVATION. Presque tous les sites connus avec *P. serraticauda* d'après la présente étude sont des concessions privées et donc ne sont pas dotées de statuts de conservation. L'espèce n'est pas recensée au sein du Parc Zoologique d'Ivoloina, un site qui est inclus dans sa zone de distribution en reliant Sahabefoza et l'École Primaire Publique Ambonivato deux sites avec *P. serraticauda* et présentant une altitude au dessous de 75 m. Cette absence de l'espèce pourrait être due à l'absence de biotope adéquat, cependant Madagascar Fauna Group a pris la mesure de planter des cocotiers dans ce Parc afin d'avoir l'opportunité de conserver cette espèce *in situ*. Étant donné que l'espèce est observée au sein des habitations humaines, le moyen de protéger l'animal serait alors de promouvoir la conservation avec les propriétaires des terrains et de continuer la sensibilisation des populations locales et riveraines, des autorités locales et régionales sur l'importance de la préservation de cette espèce.

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ARTICLE

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Early Holocene fauna from a new subfossil site: A first assessment from Christmas River, south central Madagascar

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ABSTRACT

We report on faunal remains recovered during recent explorations at 'Christmas River', the only subfossil locality known from Madagascar's south central plateau. Recovered remains of several extinct taxa date to approximately 10,000 ^{14}C years before present (BP), including crocodiles, tortoises, the elephant bird *Aepyornis*, the carnivoran *Cryptoprocta spelea,* the lemurs *Archaeolemur majori*, *Pachylemur insignis*, and *Megaladapis edwardsi*, and abundant remains of the dwarf hippopotamus, *Hippopotamus lemerlei*. The presence of southern-limited, forest-dependent species at Christmas River supports the hypothesis that forest once extended, perhaps discontinuously, across the central highlands towards the west. One theory is that sites in the north central highlands, which are higher in elevation, maintained more mesic conditions during Plio-Quaternary climate shifts than those of the lower elevation sites of the south central highlands. Thus, elevation above sea level may have acted as a filter that limited species dispersal across the island in the past. Such a scenario would explain the distinction between more humid, higher elevation, northern highland subfossil communities versus more arid, lower elevation, southern subfossil communities. Continued exploration at Christmas River thus provides a remarkable opportunity for deciphering ecological changes that have taken place in south central Madagascar during the Holocene.

RÉSUMÉ

Madagascar est reconnue comme l'une des régions les plus sensibles du monde en ce qui concerne les menaces pesant sur sa biodiversité, et cela à cause de niveaux d'endémisme inégalés, d'une diversité variée et d'un impact humain important sur l'environnement. Suite à la colonisation par l'Homme il y a plus de 2000 ans, des extinctions de masse de la faune et un important recul forestier ont eu lieu en laissant des marques sur les écosystèmes modernes qui sont dans un état de bouleversement écologique. Certaines plantes endémiques, par exemple, ont perdu d'importantes espèces mutualistes, des animaux ont été obligés d'exploiter d'autres ressources ou habiter des endroits auxquels ils sont mal adaptés. La diversité des plantes et des animaux a diminué, est menacée ou a même complètement disparue de certaines routes de dissémination. Bien que l'Homme soit largement incriminé dans son rôle de déclencheur de ces extinctions massives, les transformations anthropiques qui ont contribué au changement du climat sont controversées. Les hautes-terres de Madagascar sont actuellement dominées par des zones herbeuses étendues qui agissent comme des barrières empêchant les mouvements de la faune de part et d'autre de l'île. Nous suggérons qu'une forêt humide plus ou moins continue devait s'étendre sur les hautes-terres. Des informations paléoécologiques des hautes-terres du Centre sud sont nécessaires pour évaluer cette hypothèse afin de démêler la contribution relative des facteurs climatiques et anthropiques dans les changements paléoécologiques de la région. Cependant, les stations de subfossiles étaient jusqu'alors inconnues dans cette région.

Nous présentons ici les résultats de recherches réalisées sur les restes fauniques découverts au cours de fouilles récentes à Christmas River, la seule station de subfossiles connue des hautes-terres du Centre sud de Madagascar. Des restes de plusieurs espèces datant approximativement de 10,000 ^{14}C B.P. ont été identifiés dont des restes appartenant à des espèces de crocodile, de tortue, de l'*Aepyornis*, du carnivore *Cryptoprocta spelea*, des lémuriens *Archaeolemur majori, Pachylemur insignis* et *Megaladapis edwardsi* ainsi que de nombreux restes de l'hippopotame nain *Hippopotamus lemerlei.* La présence à Christmas River d'espèces sylvicoles endémiques du Sud appuie l'hypothèse de l'existence d'une forêt, certainement discontinue, mais qui s'étendait sur les hautes-terres centrales en se

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poursuivant vers l'ouest. Une théorie a proposé que les sites septentrionaux des hautes-terres centrales, à des altitudes plus élevées, maintenaient des conditions plus humides au cours des changements du Plio-quaternaire que les sites méridionaux de ces hautes-terres centrales. Ainsi, dans le passé, l'altitude a du agir comme un filtre qui empêchait la dispersion des espèces d'un endroit à l'autre de l'île. Un tel scénario expliquerait la distinction entre les communautés subfossiles du nord des hautes-terres qui étaient plus humides à haute altitude et les communautés subfossiles du sud aride à basse altitude. La poursuite de l'exploration à Christmas River constitue une occasion unique pour décoder les changements écologiques qui sont intervenus dans le Sud de cette région centrale de Madagascar au cours de l'Holocène.

INTRODUCTION

Madagascar is considered a hotspot for endangered biodiversity, based on unequaled levels of endemism, species diversity, and human impact on the environment (Goodman and Benstead 2005). Following human colonization more than 2,000 years ago, Madagascar experienced well-documented megafaunal extinctions and widespread deforestation (Burney et al. 2004, Crowley 2010), leaving many elements of modern ecosystems in a state of ecological disruption. For example, endemic plants have lost important mutualists (Godfrey et al. 2008), animals have been forced to exploit resources or live in habitats to which they are poorly adapted (Cuozzo and Sauther 2006, Crowley et al. 2012, Godfrey et al. 2012), and both plants and animals have reduced, threatened, or entirely eliminated dispersal routes (Godfrey et al. 1999, Goodman et al. 2006, 2007, Muldoon et al. 2009, Muldoon 2010). Although humans are widely considered to be the primary trigger of megafaunal extinctions (Burney 1999, Burney et al. 2003, 2004, Godfrey and Irwin 2007, Crowley 2010), the relative contributions of climate change and human activities to this ecological transformation are contested (e.g., Virah-Sawmy et al. 2009a,b, 2010).

Isolated patches of modern forest that is markedly more humid than surrounding areas in the southwest at Analavelona (E44°10'0.1", S22°38'60.0"), Betandraka (E45°12'43.2", S22°47'34.8"), and Mikea (E43°28'0.12", S23°18'0.0") Forests, Zombitse-Vohibasia (E48°49'0.1", S22°37'0.12"), and Isalo (E45°19'55.2", S22°30'3.6") National Parks, and in the southeast at Grand Lavasoa (E46°43'60.0", S25°4'59.9") and Ambatorongorongo (E46°43'60.0", S25°4'59.9") may be relicts of a prior humid forest corridor across southern Madagascar (Ramanamanjato et al. 2002, Goodman and Ramanamanjato 2007, Moat and Smith 2007) (Figure 1). Today, the central highlands are dominated by grasslands that act as a significant barrier to faunal exchange across the island (Muldoon and Goodman 2010). However, the subfossil record of southern Madagascar reveals that numerous extant species once occurred in regions where they do not live today (Goodman and Rakotondravony 1996, Goodman and Rakotozafy 1997, Godfrey et al. 1999, Goodman et al. 2006, 2007, Muldoon et al. 2009). To account for these distributional records, some authors have suggested that humid forest once extended, perhaps discontinuously, across the central highlands. One hypothesis is that a forested corridor extended westward across the southern portion of the central highlands from the region of Andringitra Massif (approximately south of 20° latitude), allowing the westward dispersal of animals adapted to moist environments (Goodman and Rakotondravony 1996, Goodman and Rakotozafy 1997, Goodman and Ramanamanjato 2007). Presumably, this corridor has been fragmented by climate change (Virah-Sawmy et al. 2009a,b) or human-initiated deforestation (Ganzhorn et al. 2001, Burney et al. 2004, Consiglio et al. 2006). Building a paleoecological record of the south central highlands is essential to disentangling the relative contributions of climatic and human factors to paleoenvironmental change in this region, but subfossil sites were unknown from this area until recently. We report preliminary findings from the newly discovered paleontological site that we name 'Christmas River', located in the region of the hypothesized southern faunal corridor.

MATERIALS AND METHODS

STUDY SITE. In 2008, paleontological reconnaissance in the south central highlands of Madagascar resulted in the discovery of a significant new paleontological site. This site, called 'Christmas River', is located along the Ihazofotsy River on the east side of the southernmost region of the Isalo Massif (E45°36'21.6", S22°30'3.6", 793 m above sea level; Figure 1). Christmas River is the only subfossil locality known from this region. All fauna recovered from this locality are therefore first known regional occurrences. Christmas River was discovered following on an observation by a sapphire miner, who located a bone bed 10–15 m deep in 2006. Sapphire miners focused on the collection of large macrofossils, and the younger layers of the pit have not yet been fully explored. A sample of sediment collected from the surface and subsurface at Christmas River indicates the presence of small vertebrate and botanical remains.

Approximately 600 vertebrate specimens, representing mammals, birds, and herpetofauna, have been collected from Christmas River to date. Skeletal remains in the mammalian assemblage demonstrate a high quality of preservation and include largely complete crania, jaws, isolated teeth, and postcranial elements. All skeletal material recovered from Christmas

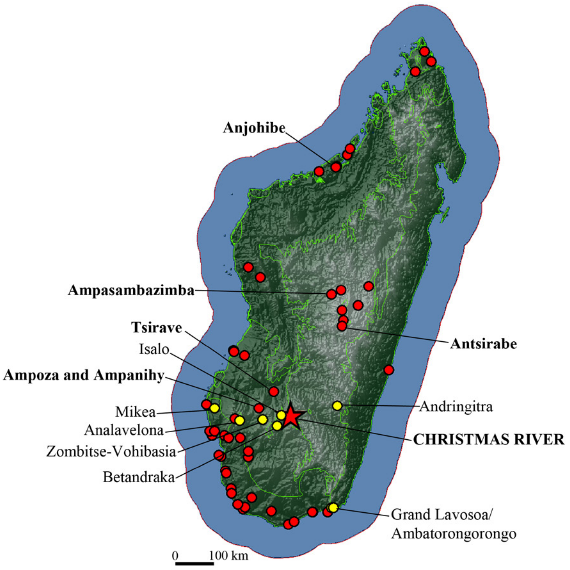

FIGURE 1. Map showing the position of Christmas River (red star), relative to modern forest sites (regular font, yellow dots) and other subfossil localities (bold font, red dots). Dashed green lines indicate the boundaries between ecoregions, following Burgess et al. (2004). Notice the unique position of Christmas River in the south central highlands, within the region of the hypothesized southern dispersal corridor.

River has been collected and studied as part of collaborative efforts between the Duke University Lemur Center, Division of Fossil Primates (Durham, North Carolina, U.S.A.), and Dartmouth College (Hanover, New Hampshire, U.S.A.), with the Département de Paléontologie et Anthropologie Biologique, Université d'Antananarivo (Antananarivo, Madagascar), respectively.

Morphological analysis of the Christmas River mammals was completed in comparison with reference material housed at the Département de Paléontologie et Anthropologie Biologique, Université d'Antananarivo (Antananarivo, Madagascar), the Natural History Museum (London, England), the Muséum national d'Histoire naturelle (Paris, France), the Naturhistorisches Museum (Vienna, Austria), the American Museum of Natural History (New York, New York, U.S.A.), The Field Museum of Natural History (Chicago, Illinois, U.S.A.), the University of Massachusetts, Amherst (Amherst, Massachusetts, U.S.A.), as well as published descriptions. Qualitative comparisons and quantitative skeletal variables were recorded for each specimen examined following anatomical landmarks defined and illustrated in Steunes (1989) and Weston and Lister (2009) for *Hippopotamus*; Jouffroy (1963) for *Archaeolemur* and *Pachylemur*; Lamberton (1934) for *Megaladapis*; Goodman et al. (2004) for *Cryptoprocta*.

We selected several bones for radiocarbon dating. These bones were decalcified and gelatinized using EDTA and weak HCl, respectively (Crowley 2012). We confirmed collagen preservation using collagen yield and atomic C:N ratios (values falling between 2.9 and 3.6 were considered well preserved). Samples were radiocarbon dated at the University of Helsinki and the Center for Accelerator Mass Spectrometry at Lawrence Livermore National Laboratory.

RESULTS

Christmas River differs from most open-air deposits in Madagascar in that it has the potential to yield a stratigraphic profile in the sense of vertical, chronological relations of sedimentary units. The deepest and most prolific layer reached so far at Christmas River is a grey-green clay containing the bones of several extinct taxa including crocodiles, tortoises, the elephant bird *Aepyornis*, and abundant remains of the dwarf hippopotamus, *Hippopotamus lemerlei.* Bones from this layer yielded AMS ^{14}C dates of approximately 10,000 uncalibrated ^{14}C years BP (Table 1). The *Hippopotamus* specimens from Christmas River therefore represent the oldest data for this genus in Madagascar.

The *Hippopotamus* specimens from Christmas River can be attributed to *H. lemerlei* on the basis of the following qualitative characters: a thick supraorbital margin that results from a large frontal sinus that extends laterally, an orbit that is taller than it is wide, the anterior margin of the orbit is situated above the third upper molar (M3), a long and flat mandibular symphysis (Figure 2a–c). The Christmas River specimens are intermediate in size between *H. lemerlei* and *H. madagascariensis* (Figure 3).

The extinct lemur *Megaladapis edwardsi* was recovered from lower levels, but did not have enough collagen to produce an accurate radiocarbon date (Figure 2g). *Megaladapis edwardsi* differs from both *M. madagascariensis* and *M. grandidieri* in having significantly larger molars (especially the third molars, which are the longest and widest). Neither of the two partial mandible specimens recovered had intact molar rows. However, one specimen preserves m2 and a partial m3, and the approximate mesiodistal lengths of all three molars were estimated from the sizes of the alveoli for the two missing teeth (m1= 18.0 mm, m2 = 24.0 mm, m3 = 35.0 mm). Based on these estimated size dimensions, both mandibles can be assigned to the larger species, *M. edwardsi* (m1 = 17.2 ± 0.6 mm [n = 43], m2 = 22.9 ± 0.9 mm [n = 63], m3 = 34.8 ± 1.5 mm [n = 70]).

TABLE 1. Radiocarbon ages for vertebrate bones collected from Christmas River. Calibrated ages were calculated using Calib 6.0, the Southern Hemisphere Calibration Curve (ShCal04) and a 20-year moving average (Stuiver and Reimer 1993, McCormac et al. 2004). Calibrated ages are rounded to the nearest 5 years. ^{14}C Laboratory Codes: CAMS = The Center for Accelerator Mass Spectrometry, Lawrence Livermore National Laboratory; Hela = University of Helsinki.

Genus and Species	Specimen #	14C yr BP ±1s	Cal yr BP ±1s	Lab #
Archaeolemur sp. cf. *A. majori*	DPC 24153a	9265 ±30	10345 ±95	CAMS 147334
Pachylemur insignis	DPC 24156	9450 ±30	10615 ±95	CAMS 147038
Hippopotamus lemerlei		9655 ±60	10955 ±215	Hela-1828
Aepyornis sp.		9610 ±60	10920 ±230	Hela 1829
Aepyornis sp.		9535 ±70	10825 ±265	Hela 1774

Isolated remains found above the grey-green clay layer include the distal left humerus of *Archaeolemur* sp. cf. *majori* that is broken just below the deltoid crest, but with a largely intact distal epiphysis and olecranon fossa (DPC 24153a; Figure 2e). This specimen dates to 9,265 ± 30 ^{14}C yr BP (Table 1). Additionally, *Pachylemur insignis* is represented by the distal two-thirds of a left femur that is broken at the level of the third trochanter (DPC 24156; Figure 2f), which yielded a date of 9,450 ± 30 ^{14}C yr BP (Table 1). These specimens exhibit diagnostic features for each genus: for example, for *Archaeolemur*, a posteromedially deflected entepicondyle; and for *Pachylemur*, a relatively deep patellar groove with a raised lateral lip and anteroposteriorly compressed femoral shaft. Both of these specimens fall within the range of size variation of the southwestern species of their respective genus (e.g., *A. majori* and *P. insignis*), although the *Archaeolemur* humerus lies at the high end of its range (Table 2), while the *Pachylemur* femur falls at the low end of its range (Table 3). We note, however, that there is a distinct latitudinal body size gradient in *Archaeolemur*, such that body size tends to be smallest in the extreme south, and larger in the center and north of the island of Madagascar (Albrecht et al. 1990, Godfrey et al. 1990). The specimen from Christmas River is larger than most specimens at sites to the south and west, but similar in size to *A. majori* humeri from Tsirave (E45°7.1', S21°49.6', 745 m a.s.l.), a subfossil site just north of the Isalo Massif.

A distal humerus (DPC 24153b; Figure 2d) attributable to the extinct carnivoran *Cryptoprocta spelea* on the basis of its large size was also recovered. The width of the distal humerus of DPC 24153b is 36.4 mm, which is larger than the same measurement in modern (27.9 ± 1.4 mm, n=12), or subfossil (32.1 ± 2.6 mm, n= 27) *Cryptoprocta ferox*, but similar in size to the larger-bodied extinct *C. spelea* (33.7 ± 1.7 mm; Goodman et al. 2004). Similar to the specimens of *Megaladapis*, collagen preservation for this specimen was too poor to produce a radiocarbon date (low yield, high atomic C:N).

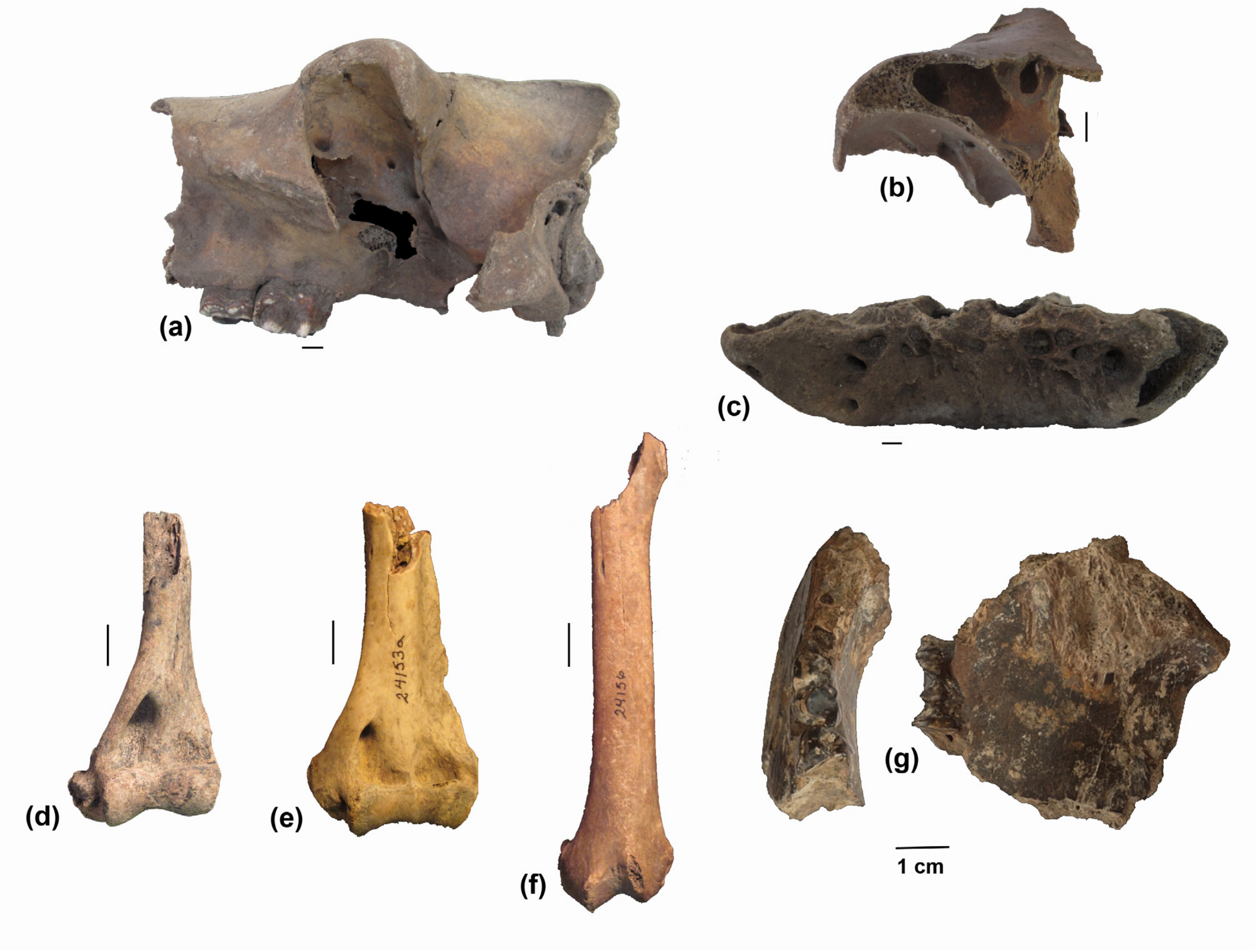

FIGURE 2. Representative mammal fauna from Christmas River. *Hippopotamus lemerlei* (a) skull (08-CR-001a) in lateral view; (b) partial skull (08-CR-002n) in posterior view; (c) mandible (08-CR-006) in anterior view; (d). *Cryptoprocta spelea* left distal humerus (DPC 24153b) in anterior view; (e) *Archaeolemur* sp. cf. *A. majori* left distal humerus (DPC 24153a) in anterior view; (f) *Pachylemur insignis* partial left femur (DPC 24156) in anterior view; (g) *Megaladapis edwardsi* (unnumbered) in occlusal and lateral views. Scale bars equal 1 cm.

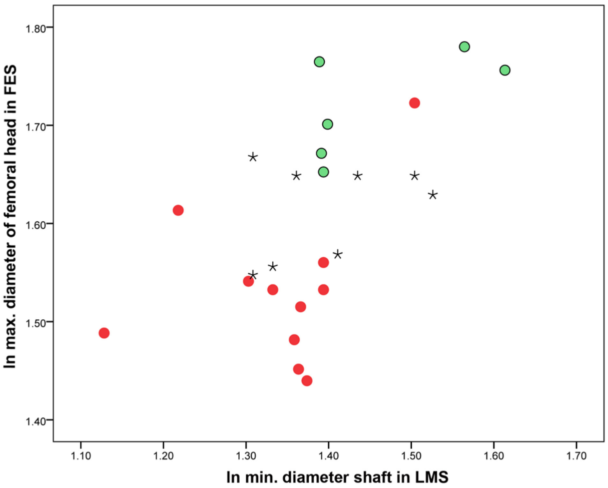

FIGURE 3. Scatterplot showing separation of *Hippopotamus lemerlei* (red dots) and *H. madagascariensis* (green dots) based on femoral measurements. The Christmas River specimens (black stars) are significantly larger than *H. lemerlei* (*t* = -3.067, *d.f.* = 20, *P* < 0.05), and significantly smaller than *H. madagascariensis* (*t* = 4.165, *d.f.* = 10, *P* < 0.05) in femoral head diameter, but cannot be distinguished from either species based on femoral shaft width (for comparisons with *H. lemerlei, t* = -1.974, *d.f.* = 27, *P* = 0.59; for comparisons with *H. madagascariensis*, *t* = -0.270, *d.f.* = 14, *P* = 0.791). FES = flexor-extensor section; LMS = lateral-medial section (following Weston and Lister 2009).

TABLE 2. Descriptive measurements for south and southwest variants of *Archaeolemur majori*, compared with specimens from Tsirave and Christmas River. Measurements (in mm) are presented as mean ± standard deviation.

	South and Southwest	Tsirave	Christmas River
Biepicondylar breadth	33.6 ± 1.5	35.7 ± 2.7	38
	n = 6	n = 6	
Trochlea to medial epicondyle	27.8 ± 1.4	29.3 ± 2.0	29.2
	n = 35	n = 6	
Trochlea + capitulum width	25.0 ± 1.4	26.0 ± 1.6	27.4
	n = 33	n = 6	
Capitulum width	10.3 ± 0.8	10.9 ± 0.5	12
	n = 34	n = 6	
Trochlear depth	11.9 ± 1.0	12.4 ± 1.6	12.4
	n = 34	n = 6	
Olecranon fossa width	16.9 ± 1.2	17.5 ± 1.0	19.5
	n = 37	n = 6	
Olecranon fossa height	9.2 ± 1.2	10.4 ± 0.8	11.4
	n = 37	n = 6	

TABLE 3. Descriptive measurements for *Pachylemur insignis* and *P. jullyi*, compared with specimens from Christmas River. Measurements (in mm) are presented as mean ± standard deviation. AP = anterior-posterior dimension.

	P. insignis	*P. jullyi*	Christmas River
midshaft AP diameter	11.8 ± 0.8	12.5 ± 0.7	10.4
	n = 14	n = 6	
midshaft transverse diameter	13.0 ± 0.8	14.3 ± 1.8	14.6
	n = 14	n = 2	
biepicondylar diameter	27.5 ± 1.4	29	28.4
	n = 14	n = 2	
bicondylar diameter	26.4 ± 1.2	28	27.8
	n = 14	n = 2	
intercondylar diameter	8.7 ± 0.8	9.5	8
	n = 14	n = 2	
patellar breadth	12.8 ± 0.9	11.5	12.9
	n = 14	n = 2	
medial condyle AP depth	23.3 ± 1.0	24.8	23.9
	n = 14	n = 2	
lateral condyle AP depth	24.1 ± 1.1	25	24
	n = 14	n = 2	

DISCUSSION

The importance of Christmas River for understanding the paleoecological history of the south central highlands of Madagascar is demonstrated by its unique fauna. The mammalian subfossil assemblage is dominated by *Hippopotamus lemerlei*, an extinct species previously recovered almost exclusively from coastal areas in the southern region of the island (Steunes 1989, Jernvall et al. 2003). The distinguishing morphological characteristics of *H. lemerlei*, which include an orbit that is taller than it is wide, suggest an amphibious lifestyle similar to *H. amphibius* of modern Africa. This is in contrast to the terrestrial habits interpreted for *H. madagascariensis*, which has been recovered from Ampasambazimba and Antsirabe, subfossil localities that occur well to the north of Christmas River in the mid-central highlands (Figure 1, Steunes 1989). We note here that attributions of the Anjohibe hippopotamus material to *H. lemerlei* (Burney et al. 1997, Samonds et al. 2010) should be corrected to *H. madagascariensis* (Weston and Lister 2009), emphasizing the geographic and ecological separation of these species that was described by Steunes (1989). The nearest subfossil localities to Christmas River are Ampoza (E44°42.3', S22°18.9', 570 m a.s.l.) and Ampanihy (E44°42.7', S22°19.8', 660 m a.s.l.), about 83 km further west (Mahé and Sourdat 1972, Jernvall et al. 2003). Although these localities yield much more recent dates (ca. 1,800 ^{14}C yr BP and 2,430 ^{14}C yr BP, respectively; Jernvall et al. 2003), the subfossil assemblages at these sites are also dominated by *H. lemerlei*.

The extinct lemur taxa shared between Christmas River and Ampoza include inferred southern forest-dwelling animals such as *Archaeolemur* sp. cf. *majori, Pachylemur insignis*, and *Megaladapis edwardsi* (Jernvall et al. 2003). This lemur assemblage is fundamentally different from the species composition of a string of subfossil sites forming a corridor crossing the central highlands well to the north of Christmas River, through the Antananarivo ex Province (especially the Vakinankaratra and Itasy regions; e.g., Ampasambazimba, Figure 1). The only characteristically southern giant lemur that is unequivocally found within this mid-central highlands corridor is *Hadropithecus stenognathus*, which is rare. Other primate taxa from the mid-central highlands include the extinct lemurs *Archaeolemur edwardsi, Megaladapis grandidieri, Archaeoindris fontoynontii, Mesopropithecus pithecoides, Pachylemur jullyi,* and *Palaeopropithecus maximus*, as well as the extant lemurs *Prolemur simus*, *Indri indri*, *Propithecus diadema*, *Eulemur fulvus*, and *Cheirogaleus major*, among others. Sites in this more northern corridor, ranging from 914 m to over 1,645 m a.s.l., are higher in elevation than those in the south.

An east-west distance effect in extant mammal distributions has been interpreted as evidence that faunal exchange routes once crossed the southern portion of the central highlands (Godfrey et al. 1999, Muldoon and Goodman 2010). It has been hypothesized that this corridor was fragmented by shifts in vegetation associated with climate change, but given that much of the natural habitat across this zone no longer exists, it is difficult to reconstruct its former extent and type. Unfortunately, the Holocene fauna of the island's eastern rainforests is currently unknown. However, the subfossil record of southern Madagascar demonstrates that several extant species currently restricted to humid forests once had more widespread geographic distributions (Goodman and Rakotondravony 1996, Goodman and Rakotozafy 1997, Godfrey et al. 1999, Goodman et al. 2006, 2007, Muldoon et al. 2009, Muldoon 2010). Furthermore, the existence of relict patches of eastern rainforest flora and fauna in the west underscores recent habitat changes in southwestern Madagascar (Ramanamanjato et al. 2002, Goodman and Ramanamanjato 2007, Moat and Smith 2007). Elements of the extant fauna and flora of these areas have been used to suggest that these isolated humid and subhumid forests may serve as refugia for biota that had much more extensive distributions in southwestern Madagascar in the recent past (Goodman and Rakotondravony 1996, Goodman and Rakotozafy 1997, Godfrey et al. 1999, Goodman et al. 2006, 2007, Muldoon et al. 2009, Muldoon 2010).

A preliminary paleoecological interpretation of the Christmas River site may offer an alternative explanation. One hypothesis is that the higher elevational distribution of sites in the north central versus south central highlands may have acted as a filter that limited species dispersal across the island in the past. Wilmé et al. (2006) proposed that watersheds with sources at high elevation maintained mesic conditions during Plio-Quaternary climate shifts due to orographic precipitation. For forest-dependent mammals, such mesic conditions may have allowed dispersal across the more northern-central passage, but limited dispersal of moisture-restricted animals in the south. For example, *Megaladapis edwardsi* is the dominant species at coastal southern sites, and may be restricted to spiny thicket habitat. *Archaeolemur majori,* and *Pachylemur insignis* are also largely restricted to the southern quadrant of Madagascar. Such a scenario would explain the distinction between more humid, higher elevation, northern highland subfossil communities versus more arid, lower elevation, southern subfossil communities. This hypothesis requires further exploration using explicit biogeographic tools.

CONCLUSIONS

The presence of forest-adapted, characteristically southern species at Christmas River provides support for two hypotheses: first, that a dispersal corridor likely once extended across the southern part of the central highlands. Preliminary evidence suggests that this corridor, perhaps discontinuously forested, could have been a northern extension of habitat typical of more southern regions, although a non-analog community of mixed eastern and southern plant communities cannot be excluded without paleoecological data. Second, it is clear that this corridor supported a primate assemblage that differed from primate communities further north. With further exploration, the faunal material from Christmas River will provide an unprecedented opportunity to decipher ecological changes that have taken place in south central Madagascar during the Holocene.

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ARTICLE

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Toponyms for centers of endemism in Madagascar

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ABSTRACT

A biogeographical model was proposed in 2006 to explain the centers of endemism and the importance of riparian forest of some watersheds as refuges or dispersal corridors during paleoclimatic oscillations. Here, we consider these geographical features highlighting their biological and sociocultural importance. We explain the etymology or eponymy of the major rivers of the retreat-dispersal watersheds, i.e., the drainage basins of Bemarivo, Antainambalana, Mangoro, Manampatrana, Mananara South, Mandrare, Onilahy, Mangoky, Tsiribihina, Betsiboka, Maevarano, Sambirano, and Mahavavy North. We propose a toponymy for each of the 15 centers of endemism and highlight their peculiarities. We named the centers of endemism of Vohimarina, Masoala, Analanjirofo, Tanala, Manombo, Anosy, Ranopiso, Karimbola, Mikea, Menabe, Melaky, Sofia, Ampasindava, Ankify, and Ankarana.

We illustrate each center of endemism with a flagship species and report on its natural and cultural histories, and conservation.

RÉSUMÉ

Un modèle biogéographique a été proposé en 2006 pour expliquer les centres d'endémisme de la biodiversité et l'importance des ripisylves de certains bassins versants en tant que refuges ou couloirs de dispersion au cours des oscillations paléoclimatiques. Ici, nous considérons ces dispositifs géographiques en soulignant leur importance biologique et socio-culturelle. Dans un premier temps, nous expliquons la toponymie ou l'éponymie des grands fleuves des bassins refuges et de dispersion, à savoir les bassins de la Bemarivo, de l'Antainambalana, du Mangoro, de la Manampatrana, de la Mananara du Sud, du Mandrare, de l'Onilahy, du Mangoky, de la Tsiribihina, de la Betsiboka, de la Maevarano, du Sambirano et de la Mahavavy du Nord. Puis nous proposons une toponymie pour chacun des 17 centres et sous-centres d'endémisme en justifiant leurs particularités. Nous retenons ainsi les centres d'endémisme de Vohimarina, de l'Atsinanana (dont Masoala et Analanjirofo), Tanala, de Manombo, de l'Anosy, d'Ala maika (dont Ranopiso, Karimbola et Mikea), du Menabe, du Melaky, de la Sofia, d'Ampasindava, d'Ankify et de l'Ankarana. Nous illustrons chacun des centres d'endémisme avec une espèce symbolique et rapportons des aspects de son histoire naturelle et culturelle ainsi que de sa conservation.

INTRODUCTION

Madagascar has a surface of 587,040 km^2, of which about 18 % is covered with forests. These forests are found from the coast to the highest mountains (>2,000 m above sea level), and represent a hyper-variable environment (Dewar and Richard 2007) with a diverse set of forest ecosystems (Moat and Smith 2007). Riparian forests along streams and rivers are found all over Madagascar and are especially obvious in the drier regions of southern, western and northern Madagascar. Madagascar is renowned for its biodiversity and high degree of local endemism (84 % for land vertebrates, 86 % for macro-invertebrates, >90 % for vascular plants) (Goodman and Benstead 2005). Remarkably, a majority of the island's endemic species are forest dwelling with ca. 90 % for land mammals, and almost 78 % for endemic bird species (Raherilalao and Wilmé 2008). As examples, among the genera of Brown lemurs (*Eulemur* spp.) or Mouse lemurs (*Microcebus* spp.), several species have radiated and adapted to a variety of these forest ecosystems on the eastern and western slopes of the island. Eastern and western Madagascar have long been the main divisions for flora and fauna (Perrier de la Bâthie 1921, Humbert 1965, Cornet et Guillaumet 1976), and more recently, as has been shown to be the case with the Mouse lemurs, a general northern and southern division has also emerged (Martin 1972, Yoder 2003).

Birds and mammals evolved during the Cenozoic era during which Madagascar was isolated from any other continental land mass (Krause 2010). There are no palaeontological records for these vertebrate groups in Madagascar, with exception of some

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BOX 1: Glossary

Center of endemism	An area exhibiting high levels of endemic species, i.e., species confined to the area and found nowhere else.
Drainage divide	The line separating neighbouring watersheds. We consider that the crest lines between adjacent watersheds are the only 'natural' lines. In hilly areas, usually in the upper watershed, the divide lies along the topographical peaks and ridges; in flat areas, usually in the lower part of the watershed, the line can be invisible.
Dispersion	Species movement away from an existing population
Local endemism	For species only encountered in a defined area of small size
Headwaters	The source of a river or stream; it refers to the furthest and highest place in that river from its estuary or confluence.
Palaeoroute	Route of dispersion at the geological scale, here limited to the Plio-Quaternary.
Refuge	A location where a relict population of a once more widespread species survives.
Watershed or catchment /drainage / water basin	An area of land delimitated by crest lines where surface water from rain converges to a single point which is the exit of a basin, and could be the estuary, a lake or a wetland, the ocean, or another river.

recent subfossils dating mostly to the last 10,000 years (Krause 2010). The study of the evolution of endemic taxa in Madagascar is based on phylogenetic and molecular approaches, which have gained momentum over the last two decades (e.g., Yoder and Nowak 2006, Horvath et al. 2008, Reddy et al. 2012). A mechanistic model (Wilmé et al. 2006) uses topography and riparian systems (i.e., riparian forests, rivers and headwaters at different elevations) combined with varying climate as principal factors to explain biogeographical patterns of local endemism. In periods of climatic change – especially during aridity – some populations may die off, others become isolated and adapt accordingly, and others may migrate and find refuge in riparian forests along rivers, which have their headwaters in the highest mountains. In times where climate shifts towards increased humidity, the reverse pathway occurs, with riparian forests expanding to lower elevations and species dispersing accordingly. Riparian forests of a watershed are therefore structural and functional pathways for species to retreat to and to disperse from. The smaller watersheds that are between these refugia-dispersion routes constitute a center of endemism (Wilmé et al. 2006).

There are only three mountainous regions in Madagascar that exceed the 2000 m elevation: Tsaratanana in the north reaching 2876 m above sea level, Ankaratra in central Madagascar to 2642 m a.s.l., and Andringitra to 2658 m a.s.l. in the south. The rivers with headwaters above 2000 m are the Bemarivo, Mahavavy, Sambirano, and Maevarano in the north, the Mangoro, Betsiboka, and Tsiribihina in central Madagascar, and the Manampatrana, Mananara, and the Mangoky rivers in the south. Wilmé et al. (2006) divided Madagascar into 12 centers of endemism, two of which are here split further (Figure 1). The objectives of this study are to name for the first time these centers of endemism. Allocating names for these centers that reflect and emphasize their particular biological and socio-cultural values will serve to link the importance of biodiversity with cultural history, and allow for the facilitation of communication between policy-makers and conservationists, when planning and managing land. We also include the names and etymology of the watersheds described in Wilmé et al. (2006), and where possible explore the reason for the current toponymy. We include a list of species that reflect the importance and character of each of the centers of endemism.

ETYMOLOGY AND TOPONYMY

People need to give names to sites or areas to be able to communicate, identify and locate them in space (Kadmon 2000). Geographical names or labels often have a meaning inspired by a location's topography, prominent landscape feature(s), hydrography, or characteristic fauna and flora. A toponym usually reduces the multidimensional complexity of a locale and abstracts the dimensions to one name representing the fundamental traits of it (Conedera et al. 2007). Table 1 lists the already existing toponymy of rivers as mentioned on the topographical

FIGURE 1. Retreat-dispersion watersheds (white – italic) and centers of endemism (colored – regular).

maps produced by *Foiben-Taosarintanin'i Madagasikar* – FTM (i.e., map at a scale of 1:500,000) from the *Institut Géographique et Hydrographique de Madagascar* which were used by Wilmé et al. (2006) for the identification of the 15 centers of endemism; here we present new names for these centers of endemism; both elaborating on the origin and meaning of the words, which in the greater part are from Malagasy. Some authors have published translations and/or etymologies of Malagasy toponyms (Grandidier 1895, Molet 1957). In most instances, the toponyms are regional and therefore only have a meaning in a regional context. We gathered information from people across Madagascar during fieldwork for biodiversity assessments by means of informal discussions with locals and present our results in Table 1 and the remainder of this section.

To decide which faunal and/or floral species could characterize a respective center of endemism, the following criteria have been applied:

1. A species needs to be locally endemic (Box 1).
2. A clear taxonomic circonscription must exist for a species (e.g., the taxon has been studied in terms of ecology, genetics, anatomy, and current distribution.
3. A species must represent an extant, not an extinct taxa (i.e., subfossils are not considered here).
4. The distribution of a species should be as widespread within a center of endemism as possible, i.e., described with confirmed data points (in section Flagship Species denoted as 'number of data points'); see also Figure 2.
5. The species must be scientifically well documented (i.e., referred to in scientific publications; in section Flagship Species denoted as 'number of references'). For this, a database research was performed using Noe4D database (Hertu and Elouard 2001, Wilmé et al. 2006) with more than 8,000 publications on Madagascar biodiversity. Noe4D database is a 4D-based software allowing for structured composite, keyword and cluster index search to manage ecological and taxonomical data regarding the terrestrial vertebrates of Madagascar. In addition, we gathered data through a structured search of published peer-reviewed literature in the online catalogues and search engines Google scholar, ISI Web of Knowledge, CAB Direct, and Tropicos.

The search for literature on this topic began in November 2011, and ended in March 2012.

In the following the 15 centers of endemism (Table 2) will be named and an etymology and eponomy provided. Each center of endemism is located on Figure 1.

Center of Endemism: VOHIMARINA
Etymology: Malagasy *vohitra* = hill, village, and *marina* = fair, honest, stable, unchanged. For the scenic coastal town of Vohimarina, also known as Iharana or Vohemar. Vohimarina is one of Madagascar's rare natural ports but is also renowned as an important archaeological site of the ancient Rasikajy culture, their distinctively appointed tombs, and carved chlorite-schist vessels, often with three legs (Vérin 1986).

Center of Endemism: MASOALA
Etymology: Malagasy *maso* = eye, *ala* = forest. The name also refers to the Masoala peninsula and more recently to Masoala National Park, which protects 220,500 ha of humid and littoral forests (Moat and Smith 2007).

Center of Endemism: ANALANJIROFO
Etymology: Malagasy *ala* = forest, *jirofo* = clove, to refer to those eastern forests where cloves have become a cash crop. Analanjirofo is also the name of an official Region since 4 October 2009.

Formerly the refuge of pirates (Dewar et al. 2010), most of the original lowland vegetation has made way for lychees, cloves, vanilla and cinnamon. Although containing several protected areas such as Mantadia, Zahamena, Ambatovaky,

TABLE 1. Etymology of the refuge-dispersion watersheds as presented in Wilmé et al. (2006) for headwaters at high altitudes.

Toponymy	Etymology, Eponymy, Explanation
Bemarivo	Malagasy *be* = plenty, and *marivo* = shallow. To explain the many places where it is easy to cross the river because of shallow waters.
Antainambalana	Also known as Antaimbalana. Malagasy *an* = place, *tai* = excrement, dung, and mivalana = flowing downstream.
Mangoro	Malagasy *mangoro* = rolling a lot of water (Molet 1957)
Manampatrana	Malagasy *manana* = to have, and *fatrana* = pasture for zebus
Mananara Sud	Malagasy *mananara* = showing rocks (Dandouan 1922)
Mandrare	Malagasy *mandry* = sleeping, and southern Malagasy dialect *areo* = you; one of the co-authors (SMSR) settled a camp next to the river in the 1990s before crossing the shallow river to conduct a tortoise inventory. On his way back, he couldn't cross the river anymore because the water rose significantly. It is expected that people have often to sleep along the banks of the Mandrare until the water level is receding. In August 2005, under clear blue sky, another co-author (LW) observed the Mandrare growing from a tiny stream to a 30m wide river in just 15 minutes.
Onilahy	Malagasy *ony* = large river, *lahy* = male or man
Mangoky	From a western Malagasy dialect *mangôky* = that digs
Tsiribihina	Also known as Tsitsobohina. Malagasy where one does not dive (Dandouan 1922)
Betsiboka	Malagasy *be* = big, *tsy* = not, and *boka* = leprous or insipid
Maevarano	Malagasy *maeva* = beautiful, and *rano* = water. Maeva can also be a name for a girl.
Sambirano	Malagasy *samby* or *samy* = each, and *rano* = water. Litterally, a river with two types of water: fresh water upstream and brackish water at the mouth (Grandidier 1895)
Mahavavy North	Malagasy *maha* = for, as a prefix, and *vavy* = female. Also suggested as 'castrate' for the large number of crocodiles in its waters (Grandidier 1895, Molet 1957).

TABLE 2. Correspondance between Wilmé et al.'s 'centers of endemism'/ 'retreat-dispersion watersheds' and 'endemism refugia' and 'dispersion refugia' as listed in Figure 1.

Wilmé et al. 2006	Toponyms
1	Vohimarina
A. Bemarivo	Bemarivo
2	Masoala
a2. Antainambalana	Antainambalana
2	Analanjirofo
B. Mangoro	Mangoro
3	Tanala
C. Manampatrana	Manampatrana
4	Manombo
D. Mananara Sud	Mananara Sud
5	Anosy
d6. Mandrare	Ranopiso
	Mandrare
6	Karimbola
e6. Onilahy	Onilahy
6	Mikea
E. Mangoky	Mangoky
7	Menabe
F. Tsiribihina	Tsiribihina
8	Melaky
G. Betsiboka	Betsiboka
9	Sofia
H. Maevarano	Maevarano
10	Ampasindava
I. Sambirano	Sambirano
11	Ankify
J. Mahavavy North	Mahavavy North
12	Ankarana

Mananara and Masoala, Atsinanana has also always been one of the major timber resources of the country (Petit and Jacob 1965). Its forests have been perceived as immeasurably large and its timber resources as being infinite. The notion that these forests could one day disappear seems so unlikely to the Malagasy that they proverbially regard these forests' disappearance to something that is totally impossible.

Center of Endemism: TANALA
Etymology: Malagasy *tan* = people of (generally, the prefix *an*- and *ante*-, previously spelled *antai*- and several variants taken to indicate 'the people' or 'the person from'), and *ala* = forest or forests, to designate a group of people of the forest (Chapman 1940). Ranomafana National Park protects 41,600 ha of humid forest.

Center of Endemism: MANOMBO
Manombo Special Reserve has one littoral forest on sand and a second parcel on ferruginous soil (Rabevohitra et al. 1998). Manombo Special Reserve contains 5,300 ha of humid and littoral forests.

Center of Endemism: ANOSY
Etymology: Malagasy *Anosy* = where islands occur (Grandidier 1895). Anosy also refers to the Anosy Mountains in southeastern Madagascar; it further represents an administrative unit since 4 October 2009. Andohahela National Park comprises three parcels: Parcel 1 (58,800 ha) covering humid forest and comprising of 45,100 ha in the Anosy Center of Endemism; Parcel 2 covering 12,800 ha, and Parcel 3 with 300 ha, both of dry-spiny forest-thicket (see Ranopiso Center of Endemism).

Center of Endemism: RANOPISO
Etymology: Malagasy *rano* = water, and *piso* = cat. In coastal areas, people talk about *amany piso*, which literally refers to 'cat's urine' to qualify a small volume of liquid, as in French. Ranopiso also refers to the main town in this small area situated between the humid eastern slope and the dry southern slope. Parcel 2 of Andohahela National Parks lies mainly (with 8,800 ha) within this center and Parcel 3 is entirely within Ranopiso Center of Endemism.

Center of Endemism: KARIMBOLA
The Karimbola is a southern region roughly delimited by the Menarandra and Manambovo rivers (Mahé and Sourdat 1972). It also refers to a clan of Mahafaly people (Bernard 1978). Tsimanampetsotsa National Park (45,800 ha) and Cap Sainte-Marie Special Reserve (2,900 ha) entail the driest forest type of Madagascar (south-western dry spiny forest-thicket, Moat and Smith 2007).

Center of Endemism: MIKEA
Etymology: *mikaike* = shout (imperative of); because, in order to meet the Mikea people in the forest, one has to shout loudly (Dina and Hoerner 1976). It also refers to an ethnic group and the only formally recognized 'indigenous peoples' in Malagasy, as defined by Operational Directive 4.20 (World Bank 1991). They are confined to the dry forests in southwestern Madagascar, with a harsh environment but one providing abundant food and material with which to build houses (Stiles 1998). The Mikea forest is defined as lying between the Manombo and Mangoky rivers, along a coastal strip west of the Antseva corridor (Molet 1958, 1966).

Center of Endemism: MENABE
Etymology: Malagasy *mena* = red, and *be* = big, to refer to the color of red soils and rivers loaded with those. The Menabe encompasses a large coastal region of western Madagascar, as illustrated by Schlemmer (1983) for the Kingdom of Menabe at the end of the 19th century (cf. Figure 4 in Schlemmer 1983). Kirindy-Mitea (81,000 ha) National Park and Andranomena Special Reserve (7,800 ha) are composed of western dry forest (Moat and Smith 2007).

Center of Endemism: MELAKY
Melaky has been considered one of the 22 Regions of Madagascar since 4 October 2009, and is situated in the central western region. The ethnic group living in this region are the Sakalava, whose main activity is cattle herding, farming and fishing. Immigrants are primarily Merina, Betsileo, and people from the Bara and Vezo among others. Immigrants tend to be farmers, small-scale traders or manual laborers. There are seven protected areas within the Melaky mainly covering western dry forests; Ambohijanahary Special Reserve (24,300 ha) is the only protected humid forest in the Melaky.

The Melaky region is crossed by an extensive network of rivers with a water plentiful throughout the year: these water resources are invaluable for many economic activities such as river and sea transport, water supplies, fisheries and agriculture. The lakes are important habitat, breeding and refuge sites for many water birds, including the Manambolomaty lake complex which holds 20 species or subspecies of waterfowl endemic to Madagascar including 10 % of the global population of the Madagascar fish eagle, *Haliaeetus vociferoides*, as well as the endemic freshwater turtle *Erymnochelys madagascariensis*, which is in steep decline. Near these lakes, particular ecological conditions allow for the thriving of plant species like evergreen *Securinega perrieri* and commercially viable species like *Commiphora* sp., *Cordylia madagascariensis*, *Dalbergia* sp. and *Hazomalania voyroni*. The shores are also characterized by the abundance of species of baobabs *Adansonia* spp.

Center of Endemism: SOFIA
Etymology: Sofia has been the name of an administrative Region since 2009 as well as that of a main river of the region. Dandouan (1922) refers to Sofia as 'the beauty' in Kiswahili, but this is not confirmed (George Paul 2012 In litt.). The eastern part of Ankarafantsika National Park (57,500 ha out of 135,000 ha) lies within this center and covers western dry forest.

Center of Endemism: AMPASINDAVA
Etymology: Malagasy *any* = at, *fasika* = sand, and *lava* = long, which makes 'at the long beach'. The name also refers to the bay of Ampasindava. Mahilaka is the oldest trading port on coastal Madagascar, linking to East Africa and the Near East, as early as 11th centuries AD (Wright et al. 2005).

Center of Endemism: ANKIFY
Eponymy: Ankify refers to the region facing Nosy Be on the mainland, the Ankify Peninsula.

Center of Endemism: ANKARANA
Eponymy: Ankarana in Malagasy means 'where there are rocks' (Grandidier 1895). Ankarana consists of a limestone plateau that does not exceed 300 m a.s.l. and that slopes gently toward the east. To the west, where it is highest, the plateau ends abruptly creating a fortress called 'wall of Ankarana', stretching 25 km from north to south. The plateau is composed of Jurassic limestone, chalk in the upper and siliceous at the base (Cardiff and Befourouack 2007). Due to rainfall, these rocks have been heavily eroded: it forms karst where the majority of formations are eroded into fantastic shapes (e.g., tower karst, sinkholes). For three million years, rain has eroded the limestone massif summit, creating fields of sharp ridges. This is where the name *tsingy* originates (meaning 'walking on tiptoes').

Ankarana is a reference to the name of the ethnic group living in this region, the Antakarana, meaning 'those who inhabit the rocks'. In the nineteenth century, their kings took refuge in the limestone caves to escape the highland ethnic groups trying to conquer them, particularly during the last war with the King Radama I (Cardiff and Befourouack 2007). The caves are royal burial sites and are places of salutary significance on a spiritual level. The Antakarana organize annual ceremonies *Fidirana an-davaka*, meaning 'enter the hole', to honor their ancestors. Every five years, a ceremony (*Tsangan-tsaina*), or 'changing of the mast', is held.

This exceptional site is protected as a special reserve covering an area of 18,225 ha. It holds great biodiversity with its moist deciduous forests including bamboos, and on the rocks, sparse xerophytic flora adapted to extreme drought conditions.

FLAGSHIP SPECIES OF THE CENTERS OF ENDEMISM

In this section, one species for each center of endemism (CE) is presented according to the criteria described previously. Their biological traits and populations are briefly depicted, and where available, an illustrative oral legend or a traditional story is presented.

CE: VOHIMARINA
Propithecus tattersalli Simons 1988
English: golden-crowned sifaka
Malagasy: *ankomba malandy*
IUCN: Critically Endangered
CITES: Appendix I
Number of data points in Noe4D: 37
Number of references: 98

The species has been described recently from a few forest remnants in northeastern Madagascar (Figure 2a). Continuous conservation and research efforts revealed higher population densities than previously thought. For example in Andranotsimaty ('where the water does not stop', Malagasy *an-rano-tsy-maty*) adjacent to the Daraïna, the population density is higher than that of *Eulemur coronatus*, despite continuous mining activities: in an area of less than 100 ha there are around 20 groups of golden-crowned sifaka each composed of 5–8 individuals. The total population is between 6,000 and 10,000 and is threatened mainly because mining for gold, sapphire, quartz and other minerals attracts numerous immigrants who do not respect the local taboo or *fady* prohibiting eating of *Propithecus*. Increased human activities in the forests for timber products such as fire wood for cooking or construction adds pressure on these lemurs.

An interesting story associated lemurs in Madagascar in general is the following: In a particular household, the husband was very unhappy as his wife beat him on a regular basis. Such was his state of depression that he lost enthusiasm for life. His sadistic wife would not even allow him to drink rum. All day he had to work, in a prison-like marriage. One day, he addressed the God of the forest, saying: "God of the Forest, you can see how I have been unhappy for so long. You are my only hope, so please do something to help me". The God of the Forest was moved by the man's plight. So he transformed the man into a wonderful and agile animal, i.e., a lemur, allowing the man to escape his unhappy circumstances. And so originated the lemurs of Madagascar.

CE: MASOALA
Varecia rubra (É. Geoffroy 1812)
English: red ruffed lemur
Malagasy: *varimena*
IUCN: Endangered
CITES: -
Number of data points in Noe4D: 18

Number of references: 95

The ruffed lemurs are the largest members of the family Lemuridae, and this species is the largest of the genus *Varecia* (*Varecia v. variegata*, *V. v. editorum*, *V. v. subcincta*). Long considered confined to Masoala Peninsula, it has been found as far north as the Andapa Basin (Figure 2b). It is impossible to confuse with other ruffed lemurs but cross-species hybridization has produced some surprising-looking individuals – all white, all black, or red, white and black. As in many other lemurs, females dominate groups of two to 20+ individuals. Their diet consists of fruit, nectar and pollen, and includes leaves when fruits and flowers are scarcer. Females usually give birth to twins (Vasey 2005). Something distinctive about ruffed lemurs is their explosive, loud vocalizations. They are readily observable in Masoala National Park, particularly at Tampolo. Their habitat is threatened by slash and burn agriculture, illegal logging (e.g., rosewood and ebony) and consequently poaching and hunting.

CE: ANALANJIROFO
Indri indri (Gmelin 1788)
English: indri
Malagasy: *babakoto, endrina*
IUCN: Endangered
CITES: Appendix I
Number of data points in Noe4D: 83
Number of references: 191

Considered largest of the extant lemurs, sometimes entirely white in color and sometimes entirely black (no genetic difference) according to locality, the Indri is a flagship animal of Madagascar. Their siren-like calls carry for miles and are the hall-mark sound of the island's rainforests. They are present on the east coast, from Mangoro watershed, up to Anjanaharibe Special Reserve, and the northern borders of Makira Natural Park (Figure 2c). They inhabit rainforest up to an altitude of 1800 m. Indris are diurnal, and move by jumping or bounding, even on the ground. Their diet consists of leaves and fruit and they live in groups of two to five individuals. Females are dominant, and are also larger than males. Indris are threatened by massive deforestation and the consequent fragmentation of remnants of eastern forests. Hunting and poaching in some areas pose a real threat while in others they are protected by *fady* so persecuting them is prohibited. Indris have never bred in captivity: this is probably because of their very specialised diet. Analamazaotra is the best site in which to see habituated Indri.

All Indri-related myths portray the species as a friendly animal and there is almost always a connection between indri and human origins, implying common ancestry. According to one legend, two brothers lived together in the forest. One day, one of the brothers decided to leave the forest and cultivate the land instead. He finally became the first human, but the brother who stayed in the forest became the first indri. That is why, until now, the indri still calls his brother from the forest daily.

CE: TANALA
Propithecus edwardsi A. Grandidier 1871
English: Milne-Edwards' sifaka
Malagasy: *simpona*
IUCN: Critically Endangered
CITES: Appendix I
Number of data points in Noe4D: 47
Number of references: 136

Long considered a subspecies of *Propithecus diadema*, but elevated to full species (Groves 2001, Mayor et al. 2004), the Milne-Edward's sifaka has experienced a population decline of 50 % during the last 30 years, partly due to degradation and loss of its natural habitat. It is found along a narrow strip of forest near the southeast coast between the rivers Mangoro, Onive, Manampatrana and to the limits of the Andringitra National Park (Figure 2d). It frequents rainforest at an altitude ranging from 600 to 1600 m a.s.l. In Ranomafana National Park, its density is 7.6 individuals per km², and it lives in groups of three to nine individuals. The species is diurnal and its diet consists of leaves, fruits, flowers and buds of some 25 known plant species (Hemingway 1998). Slash and burn agriculture is the main threat facing this charismatic species, diminishing its natural habitat and bringing about excessive fragmentation of forest remnants. Hunting is also a threat but only in the north of its range, because many people protect it further south. Because of its diet, the species does not survive in captivity.

CE: MANOMBO
Eulemur cinereiceps (Grandidier and Milne-Edwards 1890)
English: white-collared lemur
Malagasy: *varika*
IUCN: Endangered

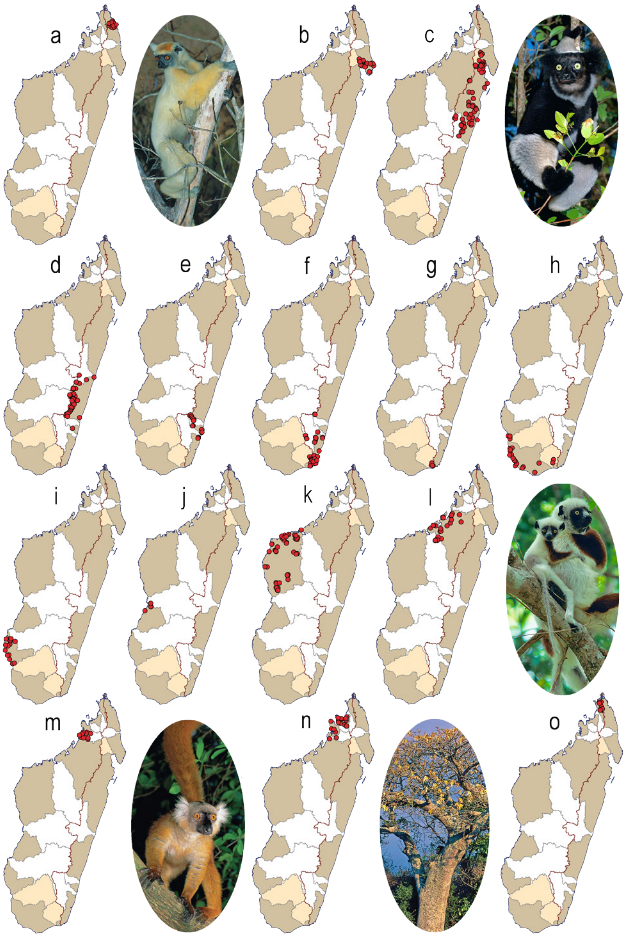

FIGURE 2. Distribution of the flagship species. (a) *Propithecus tattersalli*, (b) *Varecia rubra*, (c) *Indri indri*, (d) *Propithecus edwardsi*, (e) *Eulemur cinereiceps*, (f) *Eulemur collaris*, (g) *Dypsis decaryi*, (h) *Coua verreauxi*, (i) *Monias benschi*, (j) *Hypogeomys antimena*, (k) *Propithecus deckeni*, (l) *Propithecus coquereli*, (m) *Eulemur flavifrons*, (n) *Eulemur macaco*, (o) *Adansonia perrieri*

CITES: -
Number of data points in Noe4D: 22
Number of references: 82

Formerly known as *Eulemur albicollaris*, which has been synonymized recently (Johnson et al. 2008). Some similarities with *E. collaris* can render identification more difficult, but differences in pelage on the upper limbs or cheeks are diagnostic. Like all *Eulemur* spp., it is cathemeral, i.e., it is active by day and night, alternating phases of sleep and wakefulness; it moves on all fours while using its tail as balance and can cover long distances. The species lives in groups of four to 12. Its diet consists of fruit, leaves, flowers and fungi (Ralainasolo et al. 2008). It appears to have a life span of over 20 years. Its range is very restricted, ranging from rivers Manampatrana and Mananara in the southeast of the island (especially in protected areas of Manombo and Andringitra) (Figure 2e), where it frequents the interior of primeval rainforest. The population is estimated at between 2,500 and 7,000 but decreasing. Threats include loss of habitat (deforestation, logging, slash and burn agriculture and poaching) and also, hybridization with another *Eulemur* species, *Eulemur rufifrons* (Johnson and Wyner 2000).

CE: ANOSY
Eulemur collaris (É. Geoffroy 1812)
English: collared brown lemur
Malagasy: *varika*
IUCN: Vulnerable
CITES: Appendix I
Number of data points in Noe4D: 54
Number of references: 108

Eulemur collaris is restricted to southern Madagascar, to the north of Fort Dauphin (Tolagnaro) and Mananara River (Figure 2f). Its population has experienced a 30 % decline over the past 24 years. Its population at Midongy-Sud is, however, remarkably high with around 14 individuals per km^2. It lives in groups of three to 12 individuals in the eastern forests up to an altitude of 1800 m a.s.l. Groups are matriarchal and the species is cathemeral. Its diet is primarily frugivorous, but it will also consume sap, bark, buds, flowers, and some insects (e.g., centipedes) (Irwin et al. 2005). Anthropogenic pressures (hunting) and habitat destruction remain the key threats to its survival. It adapts well to conditions in captivity.

CE: RANOPISO
Dypsis decaryi (Jum.) Beentje & J. Dransfield
English: triangulated palm
Malagasy: *laafa*
IUCN: Vulnerable
CITES: Appendix II
Number of data points in Tropicos: 5, 14 specimens
Number of references: 5

This highly unusual palm, which blooms all year long, is confined to a very small part of southern Madagascar (Figure 2h) where roughly 1,000 individuals are presumed to remain in the wild. Outside of Madagascar however, the species is cultivated in large numbers, in many countries as it grows quickly and seeds germinate fast (Dransfield and Beentje 1995, Ratsirarson 2003). It has a smooth and upright trunk, brownish-grey in colour and marked by scars from old fronds. Overlapping leaf-bases grow from three distinct points on the trunk, forming a triangle, hence the name triangulated palm. The leaves are pinnate and they arch almost upright, measuring approximately three meters in length and one meter in width. They are segmented and bluish-green in colour. The petioles – about 1.3 m long – covered in yellowish-green blooms, support the leaves. The triangulated palm is monoecious, i.e., male and female flowers are found on the same plant. Flowers are followed by round, black fruit. Many seeds are exported for cultivation abroad.

CE: KARIMBOLA
Coua verreauxi Grandidier 1867
English: Verreaux's coua
Malagasy: *arefy, tivoka*
IUCN: Near Threatened
CITES: -
Number of data points in Noe4D: 25
Number of references: 120

The Verreaux's coua (*Coua verreauxi*) is a bird that is found only in areas of low elevation in southwest Madagascar. The distribution of *C. verreauxi* is relatively narrow in the southwest of Madagascar and the southern area of spiny forest (Tsimanapetsotsa, Cap Sainte-Marie and the Tsihombe region). In these areas its population is considered stable given the absence of specific threats (Figure 2i). The species was named after Jules Verreaux (1807–1873). Measuring about 38 cm its greenish-grey head is topped with a gray crest. The bare skin around the eyes, typical of this family, is ultramarine in the front and sky-blue behind the eyes. The iris is dark brown. The chin, throat and under-parts are white. The beak, tarsi and feet are black. The upper-parts and wings are a greenish-grey. The long tail is dark blue with metallic reflections, and marked with white on the outer tail feathers. Its diet consists of invertebrates hunted in trees and bushes and on the ground. Seasonally they also consume fruit of *Cassia* sp. (Cesalpiniaceae). The males call from treetops in November, suggesting that breeding occurs around this time. The main threat to this species is woodcutting for charcoal, which is common especially along the roads near the market towns.

There is an extract associated with this species and the origins of the radiated tortoise, taken from Decary (1964). The *tivoka* (the coua) and the *fano* (marine turtle) once had a conversation. The *fano* really wanted to visit the mainland so *tivoka* agreed to guide him. After some time, the turtle with its flattened legs, began to complain. The bird took pity on the turtle and using magic, altered the turtle's feet so it could walk comfortably. So the marine animal with its newly adapted legs continued exploring on land. Unfortunately at one point, the *tivoka* inadvertently defecated on the head of the turtle. Extremely irate, the turtle cursed its guide. Angry in turn, the bird deserted the turtle, refusing to change its legs back to their original shape. The *fano*, then wandered for the rest of its days on dry earth without ever finding the sea again. This legend refers to the origin of the land tortoises, specifically the Madagascar radiated tortoise.

CE: MIKEA
Monias benschi Oustalet & Grandidier 1903
English: Bensch's mesite, subdesert mesite
Malagasy: *naka*
IUCN: Vulnerable
CITES: -

Number of data points in Noe4D: 23
Number of references: 80

The sub-desert mesite is endemic to the southwest Mikea Forest between the Onilahy and the Mangoky watersheds (Figure 2j). It belongs to the endemic family of the Mesitornithidae. It is terrestrial, with long pinkish legs and with distinctive white eyebrows. The back is brownish-grey and the tail fairly long. The males have black spots on their white underparts, while underparts of females are variably mottled with reddish-brown and black. The bill is long and curved. It occurs in thorny Didiereaceae-*Euphorbia* thickets on sandy soil. It can tolerate severely degraded habitat. Its diet consists of invertebrates but also seeds, found by fossicking in leaf-litter, shallow water or by digging in the sand. Like all mesites, this species flies only to reach the roosting sites, nests, or, if hard pressed, to avoid predators. Reproduction occurs throughout the year, even during the middle of the dry season. This is possible because of termite mounds, at which they feed. The nest is a platform of twigs about 15 cm diameter and five centimeters deep, lined with fresh lichens. Some pairs can construct up to five nests in one breeding season, and one or two eggs are laid in each nest (Seddon et al. 2003).

CE: MENABE
Hypogeomys antimena A. Grandidier 1869
English: giant jumping rat
Malagasy: *vosistse, votsotsa*
IUCN: Endangered
CITES: -
Number of data points in Noe4D: 9
Number of references: 71

The hare-sized giant jumping rat (*Hypogeomys antimena*) is the largest rodent and the only monogamous rodent in Madagascar. It has long and pointed ears; a bulbous pink nose, short honey-coloured fur and large hind feet which enables it to hop like a miniature kangaroo around its dry, baobab-dominated forest home in the Menabe region. To escape predators, it can leap almost three feet into the air (Sommer 1996). This scarce endemic mammal, which inhabits a tiny range of just 400 km^2 in which its seasonally dry forest habitat is highly fragmented, is best sought at Kirindy Forest, part of the Menabe protected area north of Morondava (Figure 2k).

A pair will maintain a territory of about four hectares, and in it, create a complex of tunnels, about 45 cm wide, and up to five meters long, and down to about one meter below the ground. Strictly nocturnal, they emerge at dusk to feed on fruit and seeds. Food is consumed in a manner similar to squirrels: it is held in the forepaws and placed into the animal's mouth while it sits semi-upright on its haunches. One or two youngsters are usually born in the brief rainy season from December to March. The offspring remain with their parents for varying lengths of time: 2–3 years if female and 1–2 years if male. Threats to the species include habitat loss due to slash and burn agriculture and predation from introduced species such as feral dogs and cats.

CE: MELAKY
Propithecus deckeni Peters 1870
English: Decken's sifaka
Malagasy: *sifaka, tsibahaka*
IUCN: Vulnerable
CITES: Appendix I
Number of data points in Noe4D: 56
Number of references: 65

Long considered a subspecies of *Propithecus verreauxi* but recently elevated to full species status (Groves 2005), this sifaka is found in disparate patches of forest in western Madagascar, between the Tsiribihina and Betsiboka watersheds (Figure 2l). Its exact distribution is difficult to define because the presence of *P. coronatus*; some hybridization between these two species has occurred (Thalmann et al. 2002). It inhabits the dry forests and lives in groups of two to ten individuals. It is found in the following protected areas: Tsingy de Bemaraha National Park, Baly Bay and the Ambohijanahary Special Reserves. The species' population has been reduced by 30 % over the past 30 years. Threats to its habitat are continuous: forests are increasingly fragmented as trees are felled for charcoal production and to create pasture for grazing. However, there are also some very strong taboos preventing hunting of the species.

CE: SOFIA
Propithecus coquereli (A. Grandidier 1867)
English: Coquerel's sifaka
Malagasy: *sifaka, tsibahaka*
IUCN: Endangered
CITES: Appendix I
Number of data points in Noe4D: 33
Number of references: 78

Coquerel's sifaka is encountered in the Sofia region lying between Betsiboka and Maevarano watersheds (Figure 2m) and is mainly protected in the Ankarafantsika National Park (with about 60 individuals per km²) and at Anjajavy. Groups live within territories ranging from four to nine hectares. The species feeds on leaves, flowers, buds, fruits or bark depending on season (Ganzhorn 1988). The main threats which have led to a 50 % decrease in its population over the last 30 years are destruction of its habitat (bush fires for pasture, logging, felling of trees for charcoal production) but also poaching by migrant people despite local taboos that prohibit hunting it. It is present in some zoological gardens including in the USA.

CE: AMPASINDAVA
Eulemur flavifrons (Gray 1867)
English: Sclater's lemur or blue-eyed black lemur
Malagasy: *akomba sy manga maso*
IUCN: Critically Endangered
CITES: Appendix I
Number of data points in Noe4D: 12
Number of references: 79

Long considered a subspecies of *Eulemur macaco*, *E. flavifrons* is now regarded as a full species (Mittermeier et al. 2008). It is found in a very narrow area on the peninsula Sahamalaza ('the famous valley') and in a thin strip of forest around Befotaka ('much mud') and south of the Manongarivo (Litt. 'above a thousand rivers', Grandidier 1895) (Figure 2n). For a hundred years until 1983, of its rediscovery, the scientific community raised many questions about its existence and survival. Today its population, which has decreased markedly, is estimated somewhere between 2,780 and 6,950 (Schwitzer et al. 2005). *E. flavifrons* is found in highly fragmented forests. The destruction of these fragments by shifting slash and burn cultivation threatens the remaining populations to an increasing extent. However, it seems well adapted to secondary forests. Groups consist of six to 10 individuals (usually four to seven adults) and are cathemeral. Like other *Eulemur*, their diet consists mainly of fruit and seasonally they consume leaves and flowers.

CE: ANKIFY
Eulemur macaco (Linnaeus 1766)
English: black lemur
Malagasy: *ankomba joby*
IUCN: Vulnerable
CITES: Appendix I
Number of data points in Noe4D: 20
Number of references: 70

It was for a long time considered that this species included two subspecies: *Eulemur m. macaco* and *E. macaco flavifrons*), until 2006 when all the subspecies of *Eulemur* spp. were elevated to full species, the black lemur being *E. macaco* (Mittermeier et al. 2008). Morphological and genetic differences between the two species led to this distinction. *Eulemur macaco* is found from the Mahavavy river east to the river of Ambilobe Andranomalaza ('water-famous', Malagasy *and-rano-malaza*), in forests and to Ampasindava and Nosy Faly (the 'happy island') and also on the islands of Nosy Tanikely ('the small island of land') and Nosy Komba where it was introduced (Figure 2o). Where it coexists with *E. flavifrons* in some areas, the two species do hybridize. Black lemurs easily adapt to modified habitat, and like other *Eulemur* spp. are cathemeral, moving in martiarchal groups of two to 15 individuals. Their diet is varied although mostly frugivorous. As with many lemurs they are agents of seed dispersal, as some species of tree require a passage through the gut of an animal in order to germinate (Birkinshaw 1999). Major threats to this species include the destruction of its natural habitat, poaching and domestication. However they are easily bred in captivity and reintroduction programs could be established in the case of increased human pressure.

CE: ANKARANA
Adansonia perrieri Capuron 1960
English: Perrier's baobab
Malagasy: *bozy*
IUCN: Endangered
CITES: -
Number of data points in Noe4D and Tropicos: 4 and 9, 12 specimens
Number of references: 3

The baobabs belong to the genus *Adansonia* (Malvaceae) with one species in Africa (*A. digitata*) also introduced to Madagascar, one species in Australia and six endemic species to Madagascar. Madagascar is clearly the center of baobab diversity but the genus originated in Africa (Baum et al. 1998). *A. perrieri* opens its flower during the night and produces most of its nectar between 2100h and 0300h. It is primarily pollinated by large hawkmoths with body sized of 5–6 cm and proboscides exceeding 20 cm. Among these hawkmoths, *Xanthopan morgani* has been reported to visit Perrier's baobab flowers at anthesis. *X. morgani* is the pollinator that was predicted to exist by Darwin for a Malagasy orchid and the Malagasy subspecies has thus been named *X. morgani praedicta* (Baum 1995). It is confined to the northern region, where it has been recorded from five sites (Figure 2p). Only one of them, Ambondromifehy, contains more than a dozen individuals. This baobab is threatened by habitat destruction, especially bush fires, the collecting of firewood and illegal logging. Rats as seed predators also pose a significant threat. It is said to occur in Analamerana Special Reserve.

Legends surrounding baobabs invariably point towards their common nickname of 'upside-down tree'. One example is that baobabs were initially graceful trees, which delighted in boasting about their aesthetic qualities, much to the annoyance of other, more uninteresting-looking trees. In response to complaints by the other trees, God saw to it that seeds of baobabs sprouted upside-down and the roots grew upwards, and the branches down into the earth. Similarly, an Arabian legend pertaining to the Malagasy baobabs (known as *za*, *ringy* or *boringy*) holds that the devil ripped out the baobab, planted its branches into the earth, and left its roots in the air. Another legend referring to the 'upside down tree' claims that a long time ago, the baobab wanted to be the most beautiful of all trees. On realizing this was not the case, it became angry and buried its canopy, leaving the roots at the top.

FINAL REMARKS

Wilmé et al.'s 2006 watershed approach demonstrates that riparian forests in Madagascar have had an important role in geological times as refuges for fauna and flora. Riparian forests are also dispersion corridors and in some instances were probably able to link eastern with western slopes; in dry periods they can act as retreat and in wetter periods act as dispersion routes. These possible palaeoroutes between opposite slopes are still in need of documentation, but their existence could also explain the difficulty of finding a latitudinal pattern in plant or animal diversity. We therefore recommend considering riparian forests as important components for conservation biodiversity under climate change.

For clear communication at national and international levels, a proper naming of a place or region according to standardized rules is crucial (Andriamihaja 1984). Our sense of locality is clearly expressed in terms of names of places or regions. Toponymy has the potential to enrich the understanding of local environments, which can also create a culturally appropriate curriculum. Biodiversity and its endemic features, here represented by the centers of endemism and the 15 flagship species, contribute to peoples' attachment to a particular place and become part of a person's identity (Horwitz et al. 2002).

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SUPPLEMENTARY MATERIAL.

AVAILABLE ONLINE ONLY.

TABLE S1. Table listing the documents (with lat/long/time/specimen#/ref) for each of the Data Points in Figure 2.

TABLE S2. Table of references for the 15 species (775 references)

SHORT NOTE

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Notes on bat diversity at Berenty Private Reserve and Beza Mahafaly Special Reserve in southern Madagascar

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ABSTRACT

Surveys of bat diversity are rare for the southern domain of Madagascar. Mistnetting for bats took place at Berenty Private Reserve in southeastern Madagascar during a six months study in 2009 and at Beza Mahafaly Special Reserve in southwestern Madagascar for one month in 2011. At Berenty, *Hipposideros commersoni*, *Triaenops rufus*, *Myotis goudoti*, and *Miniopterus* spp. were captured along trails and clearings inside forests. Two bats, *T. rufus* and *Miniopterus* sp., were captured near the Beza Mahafaly Special Reserve. These captures increase the known bat diversity reported for both sites, but more surveys at Berenty and Beza Mahafaly are recommended.

RÉSUMÉ

Dans le Sud de Madagascar, les études sur les chauves-souris sont rares. Des opérations de capture furent conduites dans la réserve privée de Berenty dans le cadre d'une étude de six mois en 2009 puis dans la Réserve Spéciale de Beza Mahafaly pendant un mois en 2011. Avant cette étude à Berenty, la biodiversité microchiroptère de la réserve était méconnue. *Hipposideros commersoni*, *Triaenops rufus*, *Myotis goudoti* et *Miniopterus* spp. furent capturés le long des sentiers et dans des clairières à Berenty. La capture de *T. rufus* et de *Miniopterus* sp. près de Beza Mahafaly porta à sept le nombre d'espèces de chauves-souris répertoriées sur le site. Pour les deux réserves, il est souhaitable de mener d'avantage d'études dans des habitats variés et à des saisons différentes. Des spécimens de référence et des échantillons de tissus devraient être collectés afin de faciliter les identifications de certaines espèces de *Miniopterus*. Il est également nécessaire d'estimer la disponibilité en insectes et en dortoirs à Berenty, à Beza Mahafaly et dans d'autres localités malgaches afin de déterminer les facteurs limitants de ces sites.

INTRODUCTION

Although surveys of bats from the south of Madagascar have been conducted near coastal areas such as Toliara and Taolagnaro (Ranivo and Goodman 2007, Russell et al. 2007, Goodman et al. 2008, Goodman et al. 2009), few assessments exist for southern bat communities further inland. In southeastern Madagascar, bat surveys in humid forests near Taolagnaro revealed three species of megachiropterans and at least nine species of microchiropterans (Goodman et al. 1991, Goodman et al. 1993, Goodman 1999, Goodman et al. 2009). In contrast, the southern domain encompassing the extreme south and southwest is the most arid region of Madagascar. Bat diversity is higher in this region than in the southeast as two species of megachiroptera and at least fourteen microchiropteran species are reported (Goodman et al. 2005, Goodman et al. 2008, Goodman et al. 2009).

As part of a study examining nocturnal mammal ecology, bat activities were investigated at two sites in southern Madagascar: Berenty Private Reserve and Beza Mahafaly Special Reserve. A fruit bat (*Pteropus rufus*) colony is found at Berenty (Long and Racey 2007, Rahaingodrahety et al. 2008), but to our knowledge this research constitutes the first report on microchiropteran diversity at Berenty. Prior surveys of the bat fauna in and around Beza Mahafaly documented *Hipposideros commersoni*, *Mops midas*, *Mormopterus jugularis*, *Taphozous mauritianus*, and (rarely) *Pteropus rufus* (Goodman et al. 1993, Sussman and Ratsirarson 2006, Ratrimomanarivo et al. 2007).

METHODS

Berenty Private Reserve (E46°18′, S25°00′) is located along the Mandrare River in the southeast of Madagascar, approximately 85 km west of Taolagnaro (Jolly et al. 2006). The area surrounding Berenty is arid and dominated by spiny forest vegetation characteristic of the southern domain (Jolly et al. 2006). Bats were surveyed in both the Ankoba and Malaza gallery/scrub forests that comprise the main reserve. The two forests (approximately 240 ha) grade into each other in a corridor near several tourist lodges (Jolly et al. 2006) and contain evidence of human disturbances including roads, introduced plants, and water troughs. Beza Mahafaly Special Reserve (E44°37′, S23°39′) is found in the southwest of Madagascar, approximately 35 km northeast of Betioky. The research at Beza Mahafaly was conducted in Parcel 1 and an unprotected forest. Parcel 1 is a gallery forest fragment, approximately 80 ha in size and bordered on one side by the Sakamena River. A perimeter fence partially protects this forest from grazing animals (Sussman and Ratsirarson 2006, Youssouf and Rasoazanabary 2008). An intersection of two dirt roads separates Parcel 1 from the neighboring unprotected (approximately. 850 ha) dry, deciduous forest (Axel and Maurer 2010). In the unprotected forest, grazing by goats and cattle has resulted in the loss of groundcover and trees have been cut down so that livestock can feed on their leaves. Zebu cart trails, footpaths, and cattle corrals are found within this forest.

The bat communities at Berenty and Beza Mahafaly were examined using identical protocols. Bats were captured using 75 denier polyester bat nets (Avinet, Inc). Nets of 2.6 m x 2.6 m dimensions were placed along trails within forests as nets of this length ensured coverage of trails. Longer 2.6 m x 6 m nets were used in clearings and unpaved roads. The taxonomy of Malagasy bats was recently revised, but an updated dichotomous key to the bats of Madagascar was unavailable when research was conducted. At both sites, captured bats were identified to species using a key available online (<http://bats.mampam.com/madagascar/Key.htm>) and other reference material (see Taylor 2000, Garbutt 2007). Bats were placed in a soft capture bag and weighed using a 100 g Pesola scale. Digital calipers (Spi) were used to take metric measurements including body length and forearm length. Hair samples were cut from the bat's dorsum for isotopic analysis. Bats were held in the soft capture bag for up to one hour in order to obtain a fecal sample and then released without additional marking as identification of individual animals was not relevant to our larger study of nocturnal mammal ecology. The removal of dorsal hair prevented recaptured bats from being recounted on the night of capture, but bats may have been recounted on subsequent nights once hair regrew.

Supplementary scans were used to assess bat presence because bats may occur at a site, but avoid capture because they are able to detect nets (Berry et al. 2004). At 10-minutes intervals, a researcher monitoring the mistnet scanned the surrounding area with nightvision binoculars (Night Owl Optics, NOXB5) for one minute. The observation time, height, and activity of any bats detected during the nightvision scan were recorded. During the sampling interval, the researcher also used a bat detector (Stag Electronics, Batbox III) to survey for bat echolocation calls.

Between January and June 2009, 223 hours of netting and supplementary scans were conducted at Berenty during 59 nights. In both the late rainy season (January to March) and early dry season (April to June), nets were set in approximately 4-hours shifts following a sampling schedule that ensured an equal distribution of shifts throughout the night from sunset to sunrise. During 15 nights between June 7 and July 7, 2011, teams of researchers conducted 246 hours of netting along trails and clearings in both Parcel 1 and the unprotected forest at Beza Mahafaly. Ten hours of additional netting occurred along roads outside of Parcel 1. Because of longer austral winter nights and a shorter research schedule, nets at Beza Mahafaly were set in 7-hours shifts with an equal distribution of shifts throughout the night.

RESULTS

Berenty Private Reserve: The frequency of echolocation calls detected and of bats observed in nightvision scans were higher than the frequency of bat captures (Table 1). Two species of bats from the Family Hipposideridae were captured in the forests of Berenty: Commerson's leaf-nosed bat (*Hipposideros commersoni*) and the rufus trident bat (*Triaenops rufus*). At least two different vespertilionid bats were captured at Berenty. The Malagasy mouse-eared bat (*Myotis goudoti*) was captured once, but bent-wing bats from the genus *Miniopterus* were the most abundant bat at Berenty. The recent description of several new cryptic species of *Miniopterus* (Juste et al. 2007, Goodman et al. 2008, Goodman et al. 2009) complicated field identification of *Miniopterus* species. Two variants were identified in the field (Table 2): a small *Miniopterus* (mass: 3.0 to 7.0 grams; forearm < 40 mm) and a large *Miniopterus* (mass: 7.5 to 10.0 g; forearm > 40 mm).

TABLE 1. Bats detected and captured from January to June 2009 at Berenty Private Reserve.

	January	February	March	April	May	June
Hipposideros commersoni	1	0	1	0	0	0
Triaenops rufus	0	0	0	1	0	0
Myotis goudoti	0	0	1	0	0	0
Miniopterus spp.	4	4	8	3	1	0
Total bat captures	5	4	10	4	1	0
Total bats detected on nightvision	23	32	28	6	3	0
Total bat echolocations calls detected	29	75	57	37	21	6

Beza Mahafaly Special Reserve: During the research at Beza Mahafaly, bat echolocation calls were detected 16 times and bats were observed 58 times with nightvision scans. Only two bats were captured at the site. An individual *Triaenops rufus*, identified as a subadult based on unfused epiphyses in the finger bones, was captured on a zebu cart trail in the unprotected forest habitat. One bent-winged bat was captured on the road adjacent to Parcel 1. Unlike the grayish color of all bent-winged bats captured at Berenty, this individual was reddish in color.

DISCUSSION

The results of surveys at Berenty and Beza Mahafaly increase our knowledge of bat diversity at both sites. Prior to the research at Berenty, microchiropteran diversity was unknown for the reserve. During this study four species were identified. An additional one to two species of *Miniopterus* were found in the reserve as well. The capture of *Triaenops rufus* and *Miniopterus* sp. at Beza Mahafaly increase the reported bat diversity to seven species. Consistent with the location of mistnets in or near forests, the captured bats are all known clutter-foragers that hunt insects within forested areas (Goodman 1999, Garbutt 2007, Kofoky et al. 2007, Rakotoarivelo et al. 2007, Goodman et al. 2008, Rakotoarivelo et al. 2009). Future research should sample open habitats that may be utilized by aerial-foraging bats. Given that bats may not be equally active in all seasons, surveys should also be undertaken in different seasons to gain a more complete picture of bat diversity and abundance in the two protected areas.

TABLE 2. Body mass and forearm length of bats captured at Berenty Private Reserve and Beza Mahafaly Special Reserve.

Species at Berenty	Body mass mean (g) (n, SD)	Forearm length mean (mm) (n, SD)
Hipposideros commersoni	60.1 (2, 19.62)	81.3 (2, 5.75)
Triaenops rufus	10 (1, -)	50.6 (1, -)
Myotis goudoti	6.5 (1,-)	35.8 (1, -)
Miniopterus sp. (small)	5.4 (15, 1.30)	33.7 (15, 3.88)
Miniopterus sp. (large)	8.6(3, 1.5)	41.5(3, 1.4)
Species at Beza Mahafaly		
Triaenops rufus	6.8 (1, -)	47.0 (1, -)
Miniopterus sp.	6.5 (1,-)	38.3(1,-)

Recent genetic and morphological assessments of *Miniopterus* (Juste et al. 2007, Goodman et al. 2008, Goodman et al. 2009) revealed that the former *M. manavi* may include several cryptic species with convergent morphology. According to the revised taxonomy, *M. manavi* and *M. petersoni* are sister taxa (Goodman et al. 2009) with *M. manavi* found in the central highlands of Madagascar and *M. petersoni* in the southeast. Given the geographic separation suggested by the newer taxonomy, the 15 captures of small bent-wing bats at Berenty may represent *M. petersoni*. Three bent-wing bats captured at Berenty could not be identified to species in the field as their forearm measurements were larger than those reported for *M. petersoni* but smaller than those reported for *M. majori* (Garbutt 2007, Goodman et al. 2009). A fourth unidentified *Miniopterus* is likely *M. petersoni*, however it escaped before all measurements could be obtained. A bent-wing bat was also captured at Beza Mahafaly. Based on body mass and forearm measurements this bat likely belonged to *M. griveaudi* or *M. aelleni* which are sympatric in northern and western forests of Madagascar (Goodman et al. 2009). Alternatively, this bat may also represent a color variant of *M. petersoni*, which has been described from the southeast of Madagascar but not the southwest (Goodman et al. 2009). Future researchers at both Berenty and Beza Mahafaly should collect voucher specimens or tissue samples so that genetic information can be utilized to distinguish between the cryptic species of miniopterids (Goodman et al. 2008, Goodman et al. 2009).

Conservation Implications: Given the short duration of the survey at Beza Mahafaly and the time of year in which it was conducted, bat abundances cannot be addressed. However, the results from Berenty raise concerns because of the low number of bat captures relative to an intensive netting effort. For example, during the rainy season, only 19 individual bats of two species were captured in 108 hours of netting at Berenty. In western Madagascar, Rakotoarivelo et al. (2007) captured 162 bats from four species in forest interiors and riparian habitats during 32 hours of rainy season netting. The supplementary bat detection scans and nightvision scans in which researchers documented bats flying over nets suggest that not all bats at the site were captured. However, it is also likely that at least some of these scans resample the same individuals. The evidence suggests that Berenty bat populations are small and possibly at risk of local extinction.

A number of factors may account for the low capture frequencies at Berenty. The isolated forests at Berenty are surrounded by a sisal plantation and other agricultural activities, which may limit migration of bats into Berenty from other locations and prevent repopulation of the reserve. Low insect abundance may also be a factor. The decline in insects at the rainy season-dry season boundary (Fish 2010) may account for the decrease in bat captures during the dry season. Comparative data are needed to determine whether the overall availability of insects at Berenty is lower than at other locations in Madagascar. Another explanation may be a lack of roost sites. No rock overhangs or caves were discovered during surveys for roost sites at Berenty. Restaurants, bungalows, and outbuildings in the reserve were examined and neither roosting bats nor evidence of previous roosts were discovered. Future investigations should survey neighboring villages, which contain buildings that may support bat roosts. Finally, bats are prey items in parts of Madagascar (Goodman 2006, Jenkins and Racey 2008) and hunting pressure may be particularly high in the south which experiences frequent droughts and famines (Nussbaum and Raxworthy 2000, Jolly et al. 2006).

CONCLUSIONS

This research expands the known diversity of bats at Berenty Private Reserve to include the microchiropterans *Hipposideros commersoni*, *Triaenops rufus*, *Myotis goudoti*, and *Miniopterus* spp. At Beza Mahafaly Special Reserve, the captures of *T. rufus* and *Miniopterus* sp. increase the reported bat diversity to seven species. Future studies at both sites should include the collection of tissue samples or voucher specimens, surveys in different habitat types, and surveys during different seasons. Additional information on roost availability, insect prey, and potential predators including humans should be collected in investigate potential limiting factors at different localities throughout southern Madagascar.

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SHORT NOTE

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Multiple ectoparasites infest *Microcebus griseorufus* at Beza Mahafaly Special Reserve, Madagascar

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ABSTRACT

The mouse lemur *Microcebus griseorufus* at the Beza Mahafaly Special Reserve and general vicinity in southwestern Madagascar were surveyed for ectoparasites as part of a year-long behavioral and ecological study. Of 249 individual mouse lemurs examined, 74 were positively identified as hosting ectoparasites. Ticks from 20 mouse lemurs and lice in a subset of two individuals captured in a 90 ha gallery forest (Parcel 1) were preserved in 70 % ethanol or EDTA and stored for analysis and for identification. Two species of *Haemaphysalis* ticks are represented in the sample, *H. lemuris* and possibly *H. simplex*, a tick previously reported on tenrecs, birds and rats. Synchronous development of ticks may pose a risk for vector-borne diseases at the reserve especially during the dry season. The louse represented in the sample belongs to the order Anoplura (sucking lice), and resembles *Lemurpediculus verruculosus*, previously reported on *Microcebus rufus* in eastern Madagascar.

RÉSUMÉ

Un inventaire d'ectoparasites a été réalisé dans le cadre d'une étude de longue durée portant sur le comportement et l'écologie de *Microcebus griseorufus* dans trois parcelles forestières de Beza Mahafaly et ses environs. Sur les 249 microcèbes observés, 74 individus étaient infestés d'ectoparasites. La majorité de ces individus infestés, soit 97,3 %, provenait de la parcelle 1 de la réserve. Des poux et des tiques recensés sur ces animaux ont été immédiatement retirés puis préservés dans l'éthanol 70 % ou dans l'EDTA à des fins d'analyse et d'identification. Deux espèces de tiques ont été identifiées, *Haemaphysalis lemuris* et probablement *H. simplex,* cette dernière n'était préalablement connue que pour infester les tenrecs, les oiseaux et les rats.

Les rongeurs jouent un rôle significatif en tant qu'hôtes pour près de la moitié des larves et des nymphes d'ixodes de tiques du monde, y compris *H. simplex*. Les rats sont connus pour être des porteurs d'une population importante de différentes tiques. Ils sont ainsi les hôtes avec la plus grande tolérance. Une nouvelle forme de transmission a été identifiée à Beza Mahafaly dans laquelle *H. simplex* et d'autres espèces de tiques ont simultanément infesté des tenrecs. Ce chevauchement de plusieurs parasites forme une sorte de réserve et favorise la transmission des agents pathogènes à travers les espèces hôtes. Les tiques immatures jouent un rôle significatif dans la transmission des maladies véhiculées par les hôtes car les nymphes ainsi infectées peuvent transmettre des pathogènes aux hôtes et aux larves engorgées. À Beza Mahafaly, le microcèbe pourrait être l'hôte des formes immatures des tiques de *H. lemuris* et *H. simplex* chez lesquelles le stade larvaire et le stade nymphal sont synchrones. Ces formes immatures de tiques se nourrissent ensemble sur des individus de microcèbes. Les poux appartiennent à l'ordre des Anoploures (poux suceurs) et ressemblent à *Lemurpediculus verruculosus* qui n'était connu que pour infester *Microcebus rufus* des forêts humides de Ranomafana. Il est possible que *M. griseorufus* accueille sa propre espèce de *Lemurpediculus*, si ce n'est le cas, il faudra admettre que la spécificité de cet arthropode serait moins limitée qu'elle ne le semblait. Pour comprendre la dynamique des parasites de la réserve, des études sur l'écologie des tiques et des poux sont recommandées afin de pouvoir contribuer effectivement à l'amélioration de la protection de la réserve.

INTRODUCTION

Lemurs in the wild are known to carry lice, ticks, mites (Ward 1951, Takahata et al. 1998, Sauther et al. 2002, Durden et al. 2010), leeches and flies (Wright et al. 2009). The most prevalent species of ticks parasitizing lemurs are *Ixodes lemuris* and *Haemaphysalis lemuris* (Hoogstraal and Theiler 1959). At Ranomafana National Park, *Microcebus rufus* are parasitized by several ixodid tick species including *Ixodes lemuris* (Blanco et al. submitted), *H. lemuris* and an unidentified *Haemaphysalis* species (Durden et al. 2010).

Sucking lice of the genus *Lemurpediculus* have been found on *M. rufus* at Ranomafana (Durden et al. 2010) and cheirogalids at Fort Dauphin (Ward 1951). Chewing lice have also been found on lemurs. *Trichophilopterus babakotophilus* have been reported from *Indri indri* at Betampona Strict Nature Reserve (Junge et al. 2011) and *Lemur catta* and *Propithecus verreauxi* at the Beza Mahafaly Special Reserve (BMSR) are infested by *Trichophyloterus babakotus* (Loudon 2009).

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Four species of lemurs are found at the BMSR in southwest Madagascar; *Lemur catta, Propithecus verreauxi, Lepilemur petteri* and *Microcebus griseorufus*. BMSR is comprised of two forested areas, a 90 ha gallery forest (Parcel 1) and a larger 520 ha spiny forest (Parcel 2). A third forested area, Ihazoara, is located near the reserve although it is not part of the reserve itself. The parasite ecology of the diurnal lemurs, *L. catta* and *P. verreauxi*, has been described by Loudon (2009), but much less is known about the parasites harbored by the smaller-bodied species of nocturnal lemurs, *L. petteri* and *M. griseorufus*. Baseline data on the intestinal parasites of *M. griseorufus* at Beza Mahafaly has been documented by Rodriguez (2006); however data on ectoparasite infestations of this species is completely lacking from published literature. An opportunity arose to collect ectoparasites as part of a larger study on the behavior and ecology of *M. griseorufus* at BMSR. This study is the first to describe the ectoparasites infesting this species.

METHODS

Rasoazanabary (2011) used traps baited with banana to capture mouse lemurs during a year-long behavioral and ecological study (October 2006 to September 2007) at BMSR (E44° 34′ 20″, S23° 41′ 20″). Captured individuals were anesthetized, marked by ear clipping and had microchips inserted for easy identification using a transponder. The total number of trap nights during the year at each site was 33,120, for a total of 99,360 traps set in all three forests over the entire year. Traps were set in trees and on the ground. A full description of the trapping schedule is provided by Youssouf Jacky and Rasoazanabary (2008).

Captured individuals were examined for ectoparasites. When present, the number of ticks and their locations on the host were recorded and ectoparasites were removed before the animal was released. Ticks and lice were collected from a subsample of *Microcebus* and were preserved in 70 % ethanol or EDTA for future analysis and species identification. Images and measurements of ticks and lice were made microscopically (X 4–5) using SPOT basic imagining software. Positive identification of *Haemaphysalis lemuris* and *H. simplex* ticks was made by comparing the nymphal ticks collected with those previously described (Hoogstraal 1953, Uilenberg et al. 1979, Takahata et al. 1998). Identification of *Lemurpediculus* sp. was made by comparing nymphs in this study's sample with previous descriptions of this louse (Ward 1951, Durden et al. 2010). No voucher specimens of tick or lice were deposited in collections because all samples were needed for genetic analysis and were therefore destroyed during the DNA extraction process.

Three distinct habitats were sampled at Beza: (1) Parcel 1, a protected gallery forest adjacent to the Sakamena river, (2) Parcel 2, a protected spiny forest, and (3) Ihazoara, an unprotected dry forest (botanically similar to Parcel 2) near a village by the same name (for site map see Youssouf Jacky and Rasoazanabary (2008)).

RESULTS

A total of 249 mouse lemurs were live-trapped and examined for ectoparasites of which 74 animals were positively identified as hosting ticks. *Microcebus* were captured year-round but infested captures occurred only during the dry season (May to October) and only at Parcel 1. Ticks were primarily removed from the ears of *Microcebus* and very few were found traveling through the pelage. A subsample of 73 ticks from 20 mouse lemur individuals (including 33 larvae, 38 nymphs, and 2 males) was preserved. Six *Microcebus* presented *Haemaphysalis lemuris* nymphs and eight animals presented nymphs of a second haemaphysaline morphotype. Mean intensity for tick burden in the preserved samples was 2.7 nymphs per individual and 3.3 larvae per individual. Nymphs from both species of *Haemaphysalis* were found throughout the dry season (Figure 1); however, we did not find nymphs of both species co-feeding on single mouse lemurs. Larvae were more common during the early part of the dry season and were generally heavily engorged. Five individual mouse lemurs presented co-feeding nymphs and larvae. With the exception of three male adult ticks taken from one mouse lemur, no other adults were found in our preserved samples. Eight louse nymphs, taken from the head, under the fur, of two mouse lemurs were also preserved. The lice came from individuals that were also infested with ticks.

Insufficient DNA was obtained from ectoparasites and genetic analysis of samples was not possible. Only nymphs were used for morphological identification of tick species, as measurements on larvae were difficult due to the degree of engorgement. Many morphological characteristics distinguish the second tick morphotype from *Haemaphysalis lemuris*, most notably the shape of the mouthparts. Article one of the palps is highly reduced or absent. Ventrally, the basal concavity of the anterior margin of the basis capituli is more pronounced, as is the space between the medial edges of the palps and the chelicera and hypostome. Article three of the palpi is more rounded anteriorly and does not extend as far laterally as article two. This second tick morphotype most closely matches the accounts of Hoogstraal (1953) and Uilenberg et al. (1979) of *H. simplex* nymphs. Diagnostic characteristics from Hoogstral (1953) and Uilenberg et al. (1979) include: palpi that are wider than they are long and are broadly salient laterally; highly reduced, or absent, cornua on the basis capituli; and reduced spurs on trochanters (Figure 2). The morphology of the male ticks in our sample is also consistent with *H. simplex*. The characteristic mouthparts of the second morphotype also resemble those of the *Elongiphysalis* group; however, this group tends to have distinctly longer and sharper spurs on trochanters than do the specimen in our sample.

Total body length of the louse nymphs ranged from 1.1–1.8 mm (n=8). Their morphology is consistent with that of sucking lice belonging to the genus *Lemurpediculus*. Indeed, it closely resembles *L. verruculosus*, which previously has not been reported on western or southern mouse lemurs.

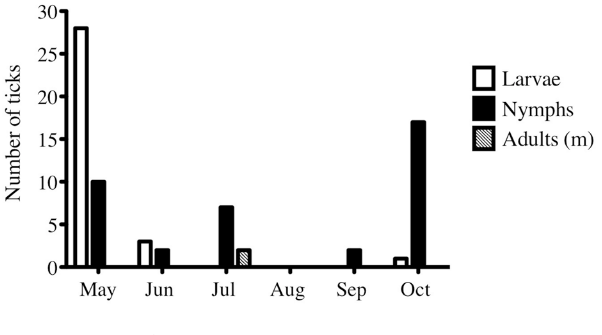

FIGURE 1. Number of preserved larval, nymphal and adult ticks removed from mouse lemurs during the winter months.

FIGURE 2. A. Dorsal view of the mouthparts of the second haemaphysaline in our sample (*Haemaphysalis* cf. *simplex*). B. Ventral view of the mouthparts. C. Ventral view of the body. D. Dorsal view of both haemaphysaline species infesting mouse lemurs at BMSR. *H. lemuris* is pictured at the top.

DISCUSSION

Two species of haemaphysaline ticks, *Haemaphysalis lemuris* and likely *H. simplex*, parasitize mouse lemurs at Beza Mahafaly Special Reserve. *H. lemuris* has also been described parasitizing both sifaka (*Propithecus verreauxi*) and ring-tailed lemurs (*Lemur catta*) at BMSR (Junge and Sauther 2002, Sauther et al. 2002, Loudon 2009). No other tick species has been associated with the lemurs at BMSR.

A combination of diagnostic characteristics of mouthparts and the tick body suggest the second tick species parasitizing mouse lemurs is *Haemaphysalis simplex*. More detailed comparisons with voucher specimen or genetic analysis can verify our tentative species assignment of this tick. The preferred hosts of *H. simplex* are *Setifer setosus* and *Echinops telfairi* but this tick species has also been found on other tenrec species (*Tenrec ecaudatus)*, rodents (*Macrotarsomys bastardi*, *Rattus rattus*) and birds (*Lophotibis c. cristata*) (Uilenberg et al. 1979). Uilenberg et al. (1979) also reported that *H. simplex* was found on the sifaka *Propithecus verreauxi*, but suggested the sifaka may have been an accidental host. The host preference of *H. simplex* may be less specific than for other tenrec tick species (Hoogstraal 1953, Hoogstraal et al. 1974, Uilenberg et al. 1979).

Haemaphysalis simplex feeding on *Microcebus* could be explained by the lack of host-specificity of this tick. At Parcel 1, mouse lemurs live in sympatry with *Echinops telfairi*, *Macrotarsomys bastardi* and *Rattus rattus*, each of which could support *H. simplex* populations and could be a source for transmission. Additionally, immature stages of ticks, as found on *Microcebus*, tend to have a wider host repertoire than do adult ticks. The presence of rats in Parcel 1 could be another factor influencing tick infestations. Rodents play a significant role as hosts to approximately half of the world's larval and nymphal ixodid ticks (Hoogstraal and Kim 1985), including *H. simplex*. Rats at the reserve are known to carry ticks (Rasoazanabary et al. 2009), although the tick species has not yet been identified. It is possible to conceive that rats can serve as vehicles for transmission of ticks between mammalian host species at BMSR. Identification of rat ticks at Beza Mahafaly is essential to elucidate tick infestation patterns.

Parasitism of *Microcebus* by multiple tick species could have important implications for vector-born diseases at the reserve. Arthropod-borne disease agents have been reported in lemurs (Uilenberg 1970, Uilenberg et al. 1972). *Haemaphysalis lemuris* may be a vector of *Babesia cheirogalei* and *B. propitheci* and *H. simplex* may serve as a vector for *B. brygooi* (Uilenberg et al. 1979). *H. simplex* can co-parasitize tenrecs with other tenrec tick species such as *H. elongata* and *H. theilerae* (Hoogstraal et al. 1974), and now possibly with *H. lemuris* on mouse lemurs. Overlapping parasitism may increase the potential for transmission of pathogens among host species. While the current study did not find nymphs of *H. lemuris* and *H. simplex* co-feeding on single mouse lemurs, this possibility cannot definitively be excluded. Additionally, immature ticks are known to play a significant role in the epidemiology of vector-borne diseases. Infected nymphs can transmit pathogens to healthy hosts and also to co-feeding larvae. At BMSR, nymph and larva are active during the dry season and their life cycles appear to be synchronous. Both stages of ticks were observed co-feeding on individual *Microcebus*. More studies of the ticks and their ecology are needed to elucidate these dynamics of parasitism at the reserve.

At BMSR, louse infestations have been reported on diurnal lemurs (Sauther et al. 2002, 2006, Loudon 2009). Loudon (2009) describes the chewing louse *Trichophyloterus babakotus* (Phthiraptera: Trichodectidae) parasitizing both ring-tailed lemurs and sifakas. The same louse species has been found on sifakas from Kirindy Mitea National Park (R. J. Lewis and D. Cailloud, pers. comm.). Different species of lice have been collected on nocturnal lemurs. Sucking lice, genus *Lemurpediculus* (Phthiraptera: Polyplacidae), have been recovered from *Lepilemur* and cheirogaleids in eastern Madagascar (Durden and Musser 1994). *Lemurpediculus petterorum* infests Lepilemur, while *L. verruculosus* parasitizes brown mouse lemurs (*Microcebus rufus*) at Ranomafana (Durden et al. 2010) and other mouse lemurs (possibly also *M. rufus*) at Bemangidy, in the region of Fort Dauphin (Ward 1951). Morphologically, the louse we found on mouse lemurs at BMSR closely resembles *L. verruculosus*. However, the latter louse species may be specific to the brown mouse lemur (Durden et al. 2010). It is possible that *M. griseorufus* has its own species of *Lemurpediculus*; if not, then the specificity of this arthropod is less restricted than previously thought. More research is therefore required to understand louse infestations in lemurs at BMSR.

CONCLUSION

Microcebus griseorufus at BMSR are parasitized by multiple species of ectoparasites, including sucking lice and a species of tick that may be acquired from sympatric species of tenrecs. Synchronous development of ticks may pose a risk for vector-borne diseases, especially during the dry season and possibly across different species of hosts. The ectoparasite profile of mouse lemurs is different from that of sympatric, larger-bodied, diurnal lemurs. The results presented here contribute to the growing compendium of knowledge on parasitism of the lemurs at BMSR and highlight the need for a comprehensive study on the dynamics of parasitism in order to fully understand the parasite ecology of the community. The ecology of parasites has implications for host health, and monitoring changes in the parasite communities can also inform researchers about the effects of altered environments on the ecosystem.

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SUPPLEMENTARY MATERIAL.

AVAILABLE ONLINE ONLY.

FIGURE S1. Ticks found on the ears of *Microcebus* at BMSR.

FIGURE S2. A. Dorsal view of *Haemaphysalis lemuris*. B. Ventral view of *H. lemuris*.

FIGURE S3. *Haemaphysalis* larvae collected on mouse lemurs at BMSR.

FIGURE S4. Ventral view of louse (*Lemurpediculus* cf. *verruculosus*) collected from *Microcebus griseorufus* at BMSR.

SHORT NOTE

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Survival of a wild ring-tailed lemur (*Lemur catta*) with abdominal trauma in an anthropogenically disturbed habitat

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ABSTRACT

Soft tissue injuries are rarely reported in wild primates as these heal fast, are not obvious, and are rapidly scavenged or decompose after death. An adult female ring-tailed lemur (*Lemur catta*) was found to have a chronic gastrointestinal fistula in Beza Mahafaly Special Reserve, Madagascar. She was observed monthly for 13 months until her remains, which showed evidence of dog predation, were found. Until then, she was in good body condition, had gained weight from the previous year and was observed to exhibit normal behaviour and produce an infant. This report documents a wild strepsirrhine primate able to survive significant soft tissue injury in an anthropogenically disturbed habitat.

RÉSUMÉ

Il est rare que des blessures dans les tissus mous soient signalés chez les primates vivant à l'état sauvage car ces blessures guérissent rapidement, sont moins visibles ou que les animaux eux-mêmes se décomposent ou sont rapidement mangés par d'autres animaux après leur mort. Une femelle adulte de lémur catta (*Lemur catta*) a été trouvée avec une fistule gastro-intestinale chronique. Elle avait été observée vivante tous les mois pendant 13 mois avant que nous ne trouvions son cadavre, qui montrait des signes de prédation par de chiens. Jusque-là, elle était en bonne condition physique, avait pris du poids par rapport à l'année précédente, montrait un comportement normal et avait donné naissance à un petit. Ce rapport documente une lésion grave des tissus mous sur un Prosimien qui a été capable de survivre dans un habitat perturbé par l'homme.

INTRODUCTION

Primates are resilient and adaptable animals as evidenced by the numerous reports of wild individuals that have survived severe injuries or congenital deformities. Many of the published reports are based on museum specimens or remains, and represent skeletal fractures or abnormalities (Bramblett 1967, Chapman and Chapman 1987, Jurmain 1989, Lovell 1990, Carter et al. 2008, Chapman and Legge 2009). In the tropics, bodies of dead animals rapidly decompose or are scavenged; therefore, even if the animal is found shortly after death, bony tissues are more likely to be found than soft tissues. Long-term field studies which regularly observe individuals can provide critical context for understanding the factors leading to injury as well as how primates cope with severe injury because researchers may know the history, age and relationship of the injured animal to the group. Injured primates in regularly observed populations are likely to be found before death or shortly after death (Kanamori et al. 2012), and can provide evidence of feral animal predation or disease that can better direct conservation efforts. Since much of the primate literature on injury and illness pertains to anthropoids, most described injuries are from great apes and monkeys, rather than strepsirrhines. Among anthropoids, living within social groups and help from conspecifics are cited as reasons why individuals with injuries or congenital abnormalities fare well (Chapman et al. 1987, Turner et al. 2008, Struhsaker et al. 2011). Reports of injuries to strepsirrhines are generally cases of attacks on infants where individuals typically die within a short period of time (e.g., infanticide) (Erhart and Overdorff 1998, Jolly et al. 2000). There is one previous report of an injured adult strepsirrhine able to survive with exposed sinuses, after severe injury to the face (Junge and Sauther 2006).

METHODS

As part of a decade-long investigation into the effects of climate and habitat change on health, behaviour, ecology, and conservation of wild lemurs living within and around the Beza Mahafaly Special Reserve (BMSR) in Madagascar, ten ring-tailed lemur (*Lemur catta*) troops have been intensively studied. Beginning

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in 2003, annual health examinations have been performed under anaesthesia on a subset of this population (Miller et al. 2007, Sauther and Cuozzo 2008, 2009). Body measurements, dental impressions, and biological samples are obtained while lemurs are anesthetized; behavioural observations are carried out throughout the year. As part of this research, an adult female ring-tailed lemur (#271 of Light Blue Troop), was examined on 21 June 2007 when she was three years old. The lemur was observed grooming, eating, and moving normally in the trees. The fur appeared matted and slightly darkened on the right side of the abdomen and thigh. She was anaesthetised using tiletamine-zolazepam (Telazol® Fort Dodge Animal Health, Fort Dodge, Iowa) and supplemented with medetomidine (Domitor®, Pfizer Animal Health, Exton, Pennsylvania) via DAN-INJECT® blow pipe, with the dart placed in the lateral distal left thigh as previously described (Larsen et al. 2011). A complete health assessment was performed including physical examination, body weight, red and white blood cell counts, differential white cell count, and serum protein (as described by Larsen et al. (2011)). Additionally, dental impressions from each quadrant and a range of body size measures were collected. Throughout examination and data collection, standard vital signs were regularly monitored and were within normal range for this population (Larsen et al. 2011). Anaesthesia was uneventful, with normal induction and recovery.

RESULTS

Upon physical examination, the lemur weighed 2.12 kg, a normal increase in body mass over the 1.42 kg she weighed when first captured as a sub-adult on 29 July 2006. She was considered to be in ideal body condition, but had patchy hair loss on the lateral aspect of the right thigh and flank; the remaining hair in these regions was matted and contaminated with faecal material. During palpation, a small amount of wet, pasty faecal material extruded from a 3 mm diameter fistula in the lower middle aspect of the right flank (Figure 1). The material had the texture and colour of normal faeces, but was not well formed, suggesting it was from the coecum or proximal colon. The skin around the hole was pink and showed no erythema, thickening, or pus, indicating that the skin was healthy and that the injury was not actively inflamed, but rather chronic in nature; an exact timeline could not, however, be determined. Several well-formed, soft faecal pellets were voided rectally during the examination, indicating that the injury was not interfering with normal gastrointestinal passage. No other abnormalities were noted during physical examination.

FIGURE 1. Intestinal contents extruding from a 3 mm diameter hole in the lower middle aspect of the right flank of wild ring-tailed lemur (*Lemur catta*) female #271. The female is laying on the table with the head to the right.

Haematology values were comparable to samples taken from this population in 2003 (Miller et al. 2007) and 2007. Results from faecal examination (direct, flotation, and faecal sedimentation techniques) were negative, further indicating that she was in good health, as 50 % of the examined population was positive for faecal parasites in 2007.

After overnight recovery from sedation, lemur #271 was released in the area where she was captured the previous morning. She then exhibited normal activity and behaviour, quickly rejoining her troop. Faeces of normal consistency had been produced overnight. Several times during the week after release, she was sighted behaving normally, for example, participating with other members of her troop in repelling the intrusion of a neighbouring lemur troop.

During the birth season (September to December) troops are censused weekly to obtain accurate birth dates. On 5 October 2007, she was observed with an infant less than one week old. However by 1 November 2007 the infant was missing and was not seen again. This infant was likely to be hers given its young age and that she was seen with the infant at each weekly census until the infant was no longer observed. Although allomothering has been occasionally observed at BMSR (Whitelaw and Sauther, unpublished data), this occurs only sporadically and given the young age of the infant when it was first observed, and the fact that most female lemurs at BMSR reproduce annually, it is most likely that this infant was the offspring of #271. Female #271 was observed monthly through the May 2008 census but disappeared by the June 2008 census. In July 2008, a local villager reported seeing a dog with lemur remains, which were then located by our research team near the BMSR research camp in an area of degraded habitat south of the protected area. She was positively identified by her numbered collar and a subcutaneous passive integrated transponder (microchip). It was unclear whether the dog had killed the lemur or had scavenged her remains. The remains were transported to our field laboratory, and upon examination, she was estimated to have been dead approximately two weeks, with most of the soft tissue missing, autolysed, or desiccated. Most portions of the skeleton were missing, the skull had been crushed, and much of the remaining skeleton was damaged.

DISCUSSION

This report describes a wild ring-tailed lemur that was clinically healthy and able to survive 13 months, behaving normally and even reproducing, with a notable wound to the abdomen and lower gastrointestinal tract. The etiology of this injury is unknown. It may have been caused by external foreign body penetration, trauma from a predator, trauma from another lemur, penetration by an internal (ingested) foreign body, or another unknown cause. Injury due to darting during capture in 2007 is unlikely as this lemur was observed the day previous to the darting with matted hair in the region found to be the location of the injury, the injury was chronic, and dart placement in the lateral right thigh was confirmed during the physical exam. Dart placement during the 2006 capture was in the left thigh with no evidence of abdominal trauma when the animal was examined. Anaesthesia of ring-tailed lemurs at BMSR has only been performed within the context of this long-term health, behaviour, ecology, and conservation project beginning in 2006. Lemurs in this troop frequently raid crops adjacent to the forest. While local cultural beliefs forbid local villagers to harm a lemur in any way (Loudon et al. 2006), humans, along with their dogs, do chase lemurs from their crops and free-roaming packs of dogs chase and attack lemurs within this area as well. Trauma from teeth or claws is a possibility although there was only a single puncture wound rather than paired or multiple puncture wounds that would be expected with teeth or claws. This etiology cannot be ruled out as injuries from other teeth or claws may not have been as deep or may have healed by the time of examination. Falls during arboreal travel, especially during inter-group fights, are relatively common in arboreal primates and have been seen in ring-tailed lemurs at BMSR. In red colobus monkeys, also an arboreal species, the most common cause of injury appears to be falls which are more common in young animals than adults (Bulstrode 1990). Possibly, the wound in this young female occurred as a result of a puncture suffered during a fall. This lemur's troop's range is in an area of dramatic anthropogenic habitat degradation (Figure 2), where they are forced to travel either high in the canopy or on the ground because the forest understory has largely been removed. The potential for falls or contact with cut trees and shrubs is thus exacerbated relative to more natural habitat such as the adjacent protected area (Whitelaw 2010).

This lemur was considered healthy and able to cope with her condition at the time of examination based on her weight gain, good body condition, physical examination, normal haematology values, and observed normal behaviour immediately after anaesthesia. Her presence within the troop and normal behaviour (agonistic intergroup participation, positive social interactions) during the ensuing 13 months suggests that there was no clinical disease. She was also seen with an infant, which suggests that she was physiologically able to carry a foetus to term and successfully give birth. The cause of death of the infant is unknown. It is possible that the female's condition was associated with the infant's death; however, infant mortality in ring-tailed lemurs in this region ranges between 18-63 % for the first month of life and averages 50 % for the first year of life (Gould et al. 2003). Feral dogs could also be involved in the death of this infant because this female inhabited a forested region in areas of high human and feral dog activity (Whitelaw 2010).

The cause of this adult female's death is equivocal, although the bony evidence is consistent with dog predation or scavenging. Since 2003, several of the authors and the local BMSR ecological monitoring team have observed serious attacks and fatal injuries on diurnal lemurs (both ring-tailed lemur (*Lemur catta*) and Verreaux's sifaka (*Propithecus verreauxi*)), by feral dogs (Brockman et al. 2008). The damage to the skull was consistent with that seen in known lemur kills by domestic dogs at BMSR, in which the head of a lemur is grasped by the dog with the mouth. For example, in 2006, a juvenile ring-tailed lemur was observed being pinned to the ground by a feral dog. This young lemur suffered severe trauma to the jaw, damaged to the point where it was unable to close its mouth and the jaw was hanging open. This lemur disappeared from the population within days of the observed dog attack.

FIGURE 2. Disturbed habitat at Beza Mahafaly Special Reserve in the area where the remains of ring-tailed lemur (*Lemur catta*) female #271 were found. Note the lack of understory and large trees to escape potential predators.

This report is unique in that objective health measures (body weight, body condition scores, parasitology, and haematology parameters) support documentation of long-term survival of a wild strepsirrhine primate with severe soft tissue injury. The ultimate demise of this female may have been determined not by her injury, but by the habitat in which she lived, where human impact on the forest is dramatic, and where predation by feral animals is common. This report attests to the resiliency of this species and underscores the importance of controlling introduced species as part conservation efforts.

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SUPPLEMENTARY MATERIAL.

AVAILABLE ONLINE ONLY.

TABLE S1. Haematology values for ring-tailed lemur (*Lemur catta*) female #271 during the 2007 season and for a sub-group of the ring-tailed lemur population at Beza Mahafaly Special Reserve, Madagascar in 2007 and 2003.

CORRIGENDUM

http://dx.doi.org/10.4314/mcd.v7i1.10

Participatory assessment of the Toliara Bay reef fishery, southwest Madagascar

Ambroise Brenier, Jocelyne Ferraris and Jamal Mahafina

Correction to: Madagascar Conservation & Development (2011) 6, 2: 60–67. http://dx.doi.org/10.4314/mcd.v6i2.4; published online 22 December 2011

On p. 63, ‘mt/y’ should be metric ton per year and not million ton per year.
Sentence should read “With the results of the household survey we were able to estimate a total production for the Toliara Bay fishery at 2,700 ± 436 metric tons per year (mt/y), and the annual yield at 14.2±2.3mt/y/km^2.”

IMPRESSUM

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