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MADAGASCAR CONSERVATION & DEVELOPMENT

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

IN THIS ISSUE

MWC

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TABLE OF CONTENTS

EDITORIAL

Looking back and thinking ahead – where next for conservation in Madagascar?

Conservation in Madagascar has seen some notable advances over the last two decades; massive policy reform and the launch of a large number of field-level initiatives have resulted in a range of new policy frameworks and institutions, a reduction in deforestation rates in many regions, the creation of numerous new protected areas and the participation of local stakeholders in new forms of natural resource governance. Such efforts have not been enough, however, to stem the tide of increasing resource degradation, and the biodiversity and functional ecosystems that underpin Madagascar's development continue to be eroded at alarming rates. These are among the conclusions of two recent reviews of the environment sector in the country, those of Freudenberger (2010) and Kiefer et al. (2010). Although different in scope, both reviews serve as useful entry points for us to reflect on progress, challenges and scenarios for the future of conservation on the island.

Kiefer et al. (2010) provides an overview of the interdependence of conservation and development in Madagascar generally, and Freudenberger (2010) focuses specifically on the interventions of USAID environment programmes over the last 25 years. Both conclude their analyses with hypothetical scenarios for the future of the conservation sector in the country. These reviews, published during the International Year of Biodiversity, provide an opportunity for reflection on the successes and failures of the environmental sector so far. At a time when the sector is facing new challenges and opportunities that will shape conservation in the decades to come (including climate change, carbon markets and REDD, population growth, political instability and increased foreign interest in Madagascar's resources), this issue of Madagascar Conservation & Development in turn provides an opportunity for further reflection on the critical question 'where next for conservation in Madagascar?'

Freudenberger's future scenarios are for the international community investing in Madagascar's sustainable development. There are, she summarises, three paths we could follow: 1) we abandon hope and give up the fight, because the challenges are simply too great, 2) we continue our current approaches, but try to do bigger and better, or 3) we collectively decide that what is at stake is so important to the world that we tear up the rule book and try radically new approaches. Kiefer et al.'s analysis, on the other hand, assumes that our collective interest in conservation will be maintained, and focuses on the respective roles of the environmental and development sectors in achieving sustainability. They argue that conservation and development are so interlinked that conservation success will only be achieved when all development sectors (including health and population, agriculture, and mining) work holistically to promote environmental sustainability in a mutually reinforcing

loop – conservation cannot happen without development, and development will not occur without a sufficient natural resource base. Both analyses converge on a number of issues: There is agreement that the stakes, for the Malagasy people, the national economy and global stakeholders, are high and reaching crisis point, and that progress towards a sustainable future depends largely on governance. We draw on two issues raised by these reports which help us imagine what kind of changes might be useful to the policy processes as well as in the actual concepts and substance of conservation policies themselves.

The interviews with social scientists in this issue add to the case made in Freudenberger's report; Tthat policy processes should be more inclusive of people from all sectors of Malagasy society, as well as both Malagasy and international thinkers from multiple disciplines. In working out how actually to implement this in practice, Madagascar could consider drawing on experience from the participatory policy planning processes developed in other developing countries through FAO National Forest Programmes (FAO 2006, O'Hara 2009). More inclusive conservation policy processes also need to be supported by good governance processes in the implementation of the resulting policies. To do this, the inclusion of forms of independent international scrutiny of governance across natural resource sectors would provide tools with which to tackle the institutionalised 'weak governance' which has plagued progress in conservation. Recent experience with the difficulties of resolving illegal precious wood exports (Ballet et al. this issue), and the negative social impacts of mining companies (Harbinson 2007, ALT and Panos 2009) illustrate the important role that international investigations and scrutiny can play in these matters. Rather than continuing this somewhat *ad hoc* and crisis-response approach, the systematic adoption of international monitoring standards would help. Models for Independent Forest Monitoring (Global Witness 2005) already exist and similar approaches could be adopted for the independent scrutiny of REDD, mining, biofuels and agricultural activities (see interviews in MCD 5(1)).

More inclusive and well informed policy processes would be expected to lead to innovation, policy reform and improved practices to produce more equitable and effective conservation. These reforms might be expected to include more effective decentralisation, more substantial economic rewards and incentives for the local people who are the custodians and customary owners of the natural resources, and to deal with one of the elephants in the room, the substantive securing of local tenure of both agricultural and forest lands. While the detail and orientation of future conservation policies is a matter for debate, we would like to use the remainder of this editorial to advocate more nuanced forms of communication by conservationists and conservation commentators. Conservation in Madagascar, as in many African nations, has become characterised by a discourse-practice divide (Benjaminson and Svarstad 2010, Büscher and de Beer In press), with relentlessly positive publicity emanating from conservation organisations extolling the virtues of their interventions (Brockington 2009) and a growing literature of critique produced by commentators on conservation (Ferguson 2010). In this issue's Spotlights article, Joerg Ganzhorn puts forward some useful approaches to remedying this situation, which otherwise risks increasing polarisation and entrenchment of positions. Among his proposals are increased collaboration between researchers and conservationists, and better availability of project reports to enable us to learn from our successes and failures. We would add to these suggestions a call for the explicit recognition of the tradeoffs which will inevitably have to be part of conservation programmes as policies are discussed, implemented and reviewed (Hirsch et al. 2010, McShane et al. 2010), and an encouragement to practitioners, policy makers and researchers alike to keep the debate alive through publishing in, reviewing manuscripts for, and reading this journal. Madagascar Conservation & Development was, after all, created as a forum for debate and exchange – let's keep using it.

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ÉDITORIAL

Un pont entre les perspectives locales et globales

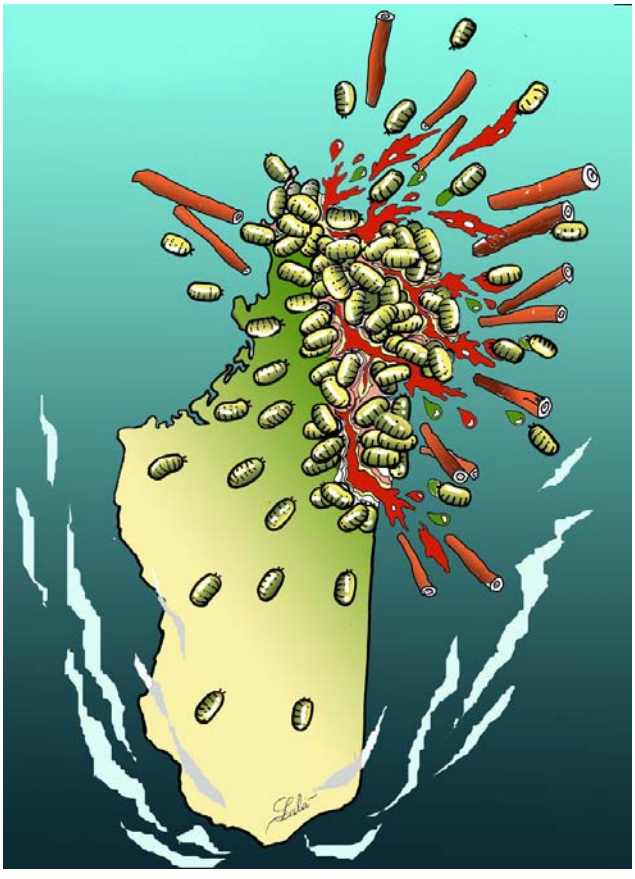
Antananarivo n'est pas Madagascar, Madagascar n'est pas l'Afrique, l'Afrique n'est pas le Monde … autant de formes qui traduisent la dualité entre local et global. Lorsqu'on imagine un domaine aux règles globales, la science et ses publications sont vraisemblablement classées en tête de liste sachant cependant que les découvertes sont bien plus souvent locales mais destinées à s'intégrer dans une dimension globale. Dans ce numéro, Noromampiandra Razafindrakoto et ses collaborateurs ont réalisé une étude sur les chauves-souris trouvant dortoir dans les bâtiments publics de Moramanga; ceci en plaçant l'étude dans un cadre global de maladies émergeantes qui sont appréhendées dans de nombreuses revues scientifiques internationales.

Alors que le volume de publications augmente, que les articles sont plus accessibles, notamment grâce à Internet, nombreux sont ceux que j'ai entendu regretter les trésors enfouis dans ce que nous désignons sous le terme de 'littérature grise' ou ces imposants volumes de rapports et études non publiés. Nous reconnaissons qu'il y a ainsi des trésors à dévoiler, mais en ne suivant pas les règles globales de la publication scientifique, les éléments pertinents se perdent dans de longs rapports non indexés et auxquels il est difficile de se référer car ils ne sont pas disponibles. Comme tous les Hommes, les scientifiques font des erreurs mais ils invitent aux critiques qui contribuent à la découverte des erreurs et leur correction. Au lendemain de Cancún, réunion globale s'il en est et sur un thème éminemment global, rappelons nous que les scientifiques indiens avaient rejeté des conclusions du groupe intergouvernemental sur l'évaluation du climat (*Intergovernmental Panel on Climate Change - IPCC*) sur la fonte des glaciers de l'Himalaya. Il s'est avéré que les extrapolations portant sur ces glaciers provenaient d'un rapport non publié, qui n'avait donc pas été soumis à un comité de lecture avec ses spécialistes ni donné lieu à une publication. De telles erreurs auraient cependant pu être publiées mais en tant que telles, elles auraient eu bien plus de chance d'être corrigées rapidement selon un processus qui a fait ses preuves. Les scientifiques indiens ont finalement identifier la source d'erreurs (Bagla 2009) mais l'affaire est maintenant citée pour démontrer la dérive dans l'utilisation de matériel insuffisamment évalué (Cogley et al. 2010). N'oublions pas qu'un comité de lecture a le plus souvent la capacité de redresser des erreurs avant publication et que lorsqu'une erreur est publiée, il peut publier une correction rapidement de sorte que les articles suivant peuvent se référer à la version corrigée.

Dans ce numéro de Madagascar Conservation & Development, Thomas Wesener et Kai Schütte, spécialistes des myriapodes, se réfèrent à des mille-pattes indiens mais décrivent le comportement d'un mille-pattes endémique de Madagascar, le plus grand du monde dans sa catégorie, qu'ils ont observé dans la forêt d'Andasibe. Les autres contributions de ce numéro présentent, elles aussi, les résultats de travaux menés localement mais toujours dans un contexte global et surtout selon un processus global et éprouvé, avec les études de Blanchard Randrianambinina dans les forêts sèches du nord-ouest ou les études de l'équipe de Gurutzeta Guillera-Arroita portant sur le lac Alaotra.

Dans le Spotlights de ce numéro, Jörg Ganzhorn sort du débat ressassé pour inviter à une mure réflexion destinée à réconcilier et réaliser simultanément la protection pérenne de la nature et le développement durable. Depuis près de 30 ans, Jörg est l'un des ambassadeurs des richesses malgaches et nous espérons avec lui que jamais la grande île ne sera banalisée. Nous avons tous assisté à une vague de descriptions d'espèces nouvelles qui ont valu de nombreuses publications aux scientifiques du monde entier et l'enrichissement des collections d'histoire naturelle, mais même si l'effort doit se poursuivre pour de nombreux groupes, la protection de la nature va devoir surfer sur cette vague pour intégrer le déve-loppement. Les sciences humaines sont encore trop discrètes à Madagascar et la parole est donnée dans ce numéro à plusieurs spécialistes des sciences humaines dans l'interview portant sur '*Social science and conservation in Madagascar*'.

Dans le seul article en français de ce numéro Jérôme Ballet et ses co-auteurs analysent les aspects économiques de l'exportation de bois précieux « illégaux » de 2009, en se basant partiellement sur un article publié dans le dernier journal de Madagascar Conservation & Development par Hery Randriamalala et Zhou Liu (2010). Cet article qui montra la relation entre l'exportation des bois précieux et les événements politiques a provoqué un phénomène inédit sur le site du journal. Jamais encore un article n'avait connu autant de téléchargements et nous avons demandé à ses auteurs comment ils expliquaient une telle popularité. Hery Randriamalala nous assure que le



nombre de téléchargements est expliqué par l'intérêt accordé par les lecteurs de Madagascar à ce dossier portant sur les bois précieux pendant cette période caractérisée par une instabilité politique. Les ébènes et bois de rose continuent d'être exploités à grande échelle dans les parcs et réserves de Madagascar mais compte tenu du moratoire adopté par les autorités, les stocks de bois continuent à croître. Il est intéressant de noter un changement d'attitude des institutions et autorités locales, avec des contrôles plus rigoureux sur le transport et dans les ports. Sur le plan international, Hery Randriamalala note le revirement de la France à l'égard de la Haute Autorité de Transition. À l'occasion de son discours du 14 juillet, l'Ambassadeur de France a pris ses distances avec ce régime et l'a exorté à juguler le trafic en cours dans ses forêts.

Nous tenons enfin à rappeler le travail remarquable réalisé par les professionnels de la presse de Madagascar pour analyser, documenter et publier sur ce trafic. Le bois de rose est devenu la figure emblématique d'un phénomène qui dépasse largement l'exploitation d'une ressource forestière et nous saluons ici un éditorialiste d'un journal de la place qui vient de citer localement un phénomène global : Les aléas ont poussé les uns et les autres à privilégier les profits à court terme au détriment des projets plus durables, et la recherche de profits sur le bois de rose a pris la place de la culture de vanille dans la région Sava (A. 2010).

Patrick O. Waeber, Rédacteur fondateur

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SPOTLIGHTS

A combined research agenda towards integrated conservation and development for Madagascar

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ABSTRACT

Better integration of social and natural science activities seems to be the key to improve the efficiency of conservation and development. While there is no recipe for success, this paper argues that conservation has to pay for itself if it wants to be anchored in present-day-societies. In systems where humans depend largely on subsistence activities, economic benefits from conservation must outweigh the benefits from increasing these activities. Coming from a natural science perspective, this paper proposes some activities that could improve the basis for decision-making and contribute to the long-term integration of sustainable conservation and development. It is argued that experiences from various projects must be evaluated and be accessible; data should be stored in a central database that can be used to develop future programs; restoration of various sorts providing direct income for the local human populations (including gardens, native and exotic tree plantations with valuable species) should be a priority; and natural science projects should add analyses of processes to the present preponderance of describing patterns. All these activities should result in integrated action to maintain natural biodiversity as a key component to maintain and improve local livelihoods.

RÉSUMÉ

La clef de la réussite pour assurer la protection de la nature et le développement passe par une meilleure intégration des activités élaborées dans le cadre des sciences sociales et celui des sciences naturelles. L'objet n'est pas ici d'énoncer les ingrédients d'une utopique recette miracle mais de montrer que la protection de la nature doit être assimilée à une activité rentable si elle veut s'ancrer dans la réalité quotidienne des sociétés humaines. Dans des systèmes où les gens sont étroitement liés aux activités de subsistance, les avantages économiques de la conservation de la nature doivent dépasser ceux de l'augmentation des activités de subsistance. En partant d'une perspective des sciences naturelles, cet article propose de considérer quelques points qui pourraient améliorer les fondements dans toute prise de décision et qui pourraient contribuer à établir une base qui servira à l'intégration à long terme de la conservation et du développement durables. Ce plaidoyer porte sur les points suivants : (1) Les expériences acquises dans les différents projets doivent être évaluées et archivées afin d'être accessibles aux élaborateurs de nouveaux projets à venir. (2) Les données doivent être stockées dans une base de données centrale qui pourra être utilisée pour élaborer de futurs programmes destinés à la gestion pérenne des espaces. Elle devra contenir les résultats de recherches intégrées et croisées sur plusieurs disciplines, de recherches appliquées aux problèmes pour les hommes et en même temps des résultats de recherches de base sur les sciences naturelles. Cet ensemble devra être accessible pour fournir des services et des conseils aux politiques, aux décideurs et aux intervenants. (3) Les activités de restauration de toutes sortes devraient être prioritaires. Il en est de la réhabilitation des jachères ou de la restauration d'écosystèmes naturels, et on trouvera des activités menées dans des jardins, des cultures de rente, des plantations arborées d'essences recherchées, qu'elles soient indigènes ou allogènes, et des habitats originels. La mosaïque d'habitats doit être élaborée de telle manière qu'elle permettra de produire des revenus directs pour les gens de la région, d'une façon ou d'une autre. Les recherches portant sur la nature devraient limiter la prépondérance actuelle à décrire des schémas pour aborder davantage des analyses portant sur les processus et fonctions. Ces analyses devraient tenter de comprendre les processus sous-jacents qui expliqueraient, non seulement la répartition actuelles des espèces mais aussi les services et fonctions fournis par les écosystèmes. Toutes ces activités devraient aboutir à des actions intégrées pour maintenir la biodiversité naturelle en tant que composante clef pour maintenir et améliorer les moyens d'existence locaux.

KEYWORDS: Restoration, database management, ecosystem function, ecosystem process.
MOTS CLEFS : Restauration, base de données, fonctions et services écosystémiques, processus écologiques.

CONTEXT

It is not very useful to grieve over the demise of Madagascar's original forest ecosystems in yet another publication. Rather, we should make an honest evaluation of what went wrong, why hundreds of millions of dollars and euros targeted for conservation and aid were unable to turn the tide (e.g., Rabesahala Horning 2008), what are the old and new challenges, and what can we do to save whatever is left. As an ecologist I have little so say about misjudgments of the social, economic and political context that contributed to the problems of effec-

tive nature conservation. Rather, from the perspective of a natural scientist, I provide some thoughts on what could be done to help improve the prerequisites for more effective conservation of Madagascar's biota and human livelihoods.

PROJECT REVIEW

With his superb background and insights, Jeffrey Sayer provided a thoughtful analysis of the current conservation and development situation in Madagascar and elsewhere (Sayer 2009). One central point of his conclusion was a call to "learn from mistakes" rather than "hiding mistakes" (see Table 1 in Sayer 2009). In order to achieve this goal, project results must be documented and documents must be available for further analyses, evaluation and as bases for the next generation of projects. However, data and documents are not available for most projects once they have come to an end. As a result, projects and mistakes are replicated over and over again without any chance to learn from past mistakes. Apart from the lack of documentation, most of the staff has been changed by the time a new project starts, and only few people remain long enough in this field to accumulate enough knowledge for comprehensive analyses (e.g., Durbin et al. 2003, 2008, Rabesahala Horning 2003, Sorg 2006, Elmqvist et al. 2007, Ratsirarson 2008). Thus, there is a need for a centralized structure for data storage, management and analyses.

DATA MANAGEMENT

About 20 years ago, a group of NGOs and Malagasy governmental institutions planned a 'Biodiversity Planning Center' for Madagascar (Smith et al. 1997). The center was to compile and store data from all kinds of conservation oriented projects. Projects carried out in Madagascar would have been obliged to deposit their data in the Center (certainly with appropriate copyright regulations; but after all, most of the work is funded by the public and therefore the public has the right to have access to the data if the people who compiled the data do not find the time to analyze and publish them). A central database and skilled data management would allow new project developers to learn what has been done already, to apply comparable methods and to address gaps in knowledge rather than duplicate efforts. This database should also have allowed meta-analyses of the reasons for successes and failures. Unfortunately, the project was not implemented. For some of the biodiversity data, this task has been taken on by private initiatives. It is no surprise that analyses of these data serve as important drivers for conservation decisions today and serve to prioritize geographical regions for conservation efforts (Wilmé et al. 2006, Kremen et al. 2008, Missouri Botanical Garden 2010, REBIOMA 2010).

Twenty years after the failure to establish such a center in Madagascar, the idea of centralized data management centers has begun to root in the political arena internationally. Thus, today, there might be more political and financial support to implement such a center than has been a few decades ago. As an example, the German government recently launched a major project to help set up Regional Science Service Centres for Adaptation to Climate Change and Sustainable Land Management (RSSC 2010) in western and southern Africa. On their webpage it states:

"This center (or a series of regional centers) should create added value by complementing the existing research and capacity development infrastructures and research initiatives. It should be embedded in the regional and national research. Its mission is to conduct problem-oriented research in the area of adaptation to climate change and sustainable land management. It should provide evidence-based advice for all decision-makers and stakeholders to improve the livelihoods of people in the region and to contribute to the creation of an African knowledge-based society. In order to meet the demands of target groups such as policy-makers and governmental administration, farmers, practitioners and other regional and local stakeholders affected by climate change, the center(s) should have the following three main objectives that are closely interrelated and that should be take into account with equal priority:

1. Trans-disciplinary, applied research for people
2. Services and advice for policy, decision-makers and stakeholders
3. Capacity development (RSSC 2010)."

This statement could easily describe the present situation in Madagascar. In principle, all aspects mentioned in the concept for the RSSC are available in Madagascar. The pieces of the puzzle simply ought to be combined. Madagascar could then be the front-runner and model of the new concept of "earth system science for global sustainability", the new political mainstream and call for better integration of social science research into the concepts for sustainable development (Reid et al. 2010). Thus, the concept of a 'Biodiversity Planning Center' for Madagascar should be revived, explicitly extended to include social sciences and adapted to suit the needs for development projects. With the appropriate structures put in place, there might be a chance for external funding, though this project would require a national financial perspective; and probably could be financed with the money coming into the country right now if activities were coordinated by a central structure.

RESTORATION

Assuming that conservation and development objectives can be achieved within the regional Malagasy socio-economic and cultural context, what may be the directions for future activities? On the human side, the very basic assumption is that people need to make money, they want to make money and they will make more money if the opportunity arises. On the natural history side, the present conclusion is that the current system of protected areas is insufficient to maintain the island's biodiversity under the scenario of climate change (Hannah et al. 2008). Especially in the west but also in the east, protected areas are isolated without connectivity to other protected areas. If the long-term trend of desiccation will continue, organisms will have to be able to retreat from dry areas to more mesic refugia. Since climate change is happening in Madagascar, can be documented with contemporary data within a decade (such as between the mid 1980s and the mid 1990s: Raxworthy et al. 2008), and is expected to result in pronounced changes until 2050 (Direction Générale de la Météorologie 2009), there is an urgent need for a comprehensive analysis for future land management.

From the perspective of biodiversity conservation, the only solution to properly address the problem of lack of connectivity seems to be to restore natural habitats between protected areas

assuming that the protected areas will be protected for some time to come (Holloway 2003). This integration of anthropogenic and 'pristine' ecosystems is one of the developing research avenues for the near future (Ellis and Ramankutty 2008). Restoration can take a variety of forms. The oldest record of forest restoration in Madagascar comes from the mountains of Ankaratra where some sort of clear-cut area has been reforested with a monoculture of native trees about 200 years ago (Goodman et al. 1996). The assemblages of bird and mammalian insectivores and rodents do not seem to differ markedly from pristine forests of the same altitude. Apart from these reports mentioned above, the documented experiences with natural forest restoration in Madagascar are very limited, as is the information of the endemic biodiversity response to anthropogenic habitats (Irwin et al. 2010).

Most reforestation projects have been done with exotic trees to cover the needs of the human population for charcoal, firewood, wood for construction, and to reduce the pressure on the remaining forest. During the last few years, many local restoration and reforestation activities with native trees have been implemented. But given that for decades GOs and NGOs have been aware that the native forest disappears and has to be replaced to maintain its services not just to maintain biodiversity but also to maintain the livelihoods for the people, it is astonishing that the largest non commercial nursery for native trees in Madagascar is run by a mining company, QIT Madagascar Minerals, with more than 30,000 trees from 200 native species produced until now (Randriatafika et al. 2007a, Vincelette et al. 2007, Rabenantoandro, pers. comm. 23 August 2010).

Restoration can be more than 'just' planting native trees. Restoration in an anthropogenic landscape could consist of a mosaic of habitats that can provide connectivity, such as gardens (not yet integrated in Madagascar, but elsewhere: Goddard et al. 2010), exotic trees (Ganzhorn 1987, Vallan 2002), wetlands (Durbin et al. 2003, 2008, Randriatafika et al. 2007b), agroforestry and native plants that are of immediate use or economic value for the local people (Schroth et al. 2004). Apart from plants that occur in monocultures naturally, such as reeds, utilitarian plants such as trees (Deleporte et al. 1996) or lianas (Rabenantoandro et al. 2007) might be planted as enrichment plantations. The recent pillage of rosewood illustrates the need but also the potential for enrichment plantations to compensate for the loss of rosewood trees and to provide valuable resources for future generations (Patel 2009, Wilmé et al. 2009, Innes 2010, Randriamalala and Liu 2010). In addition, precious trees could also be planted around gardens to serve as a 'bank account' for individual farmers as it is being done in the Amazon (Serrao1995), or, together with fruit trees, again as enrichment plantations in secondary vegetation. In addition to these approaches there are political incentives, such as added value through carbon credits (Hunt 2008), Reducing Emissions from Deforestation and Forest Degradation (REDD) (Plugge et al. 2010), or yet unexplored economic compensation for biodiversity values (Bishop et al. 2008).

In the short-term, immediate benefits from conservation and sustainable land management must exceed benefits from unsustainable land management. As a long-term perspective, people will have to acquire the insight that resources are limited. In the case of Madagascar, that the forest ends at the top of the mountain and that there will just not be any place to go once the top of the mountain has been cleared for agriculture. These types of insight and foresight are not found commonly in activities of western or in the new sky-rocketing economic cultures, such as Brazil or China, either, but the implementation of the existing laws is easier in western culture as there are options to generate alternative income that are not available to most farmers in Madagascar. Irrespective of the short-term solution and possible long-term change in perception of land management, it would be naïve to expect that somebody will always be there to compensate for missed income. At the end of the day conservation must pay its way by itself.

FUTURE DIRECTIONS FOR RESEARCH

Recent buzzwords for research agendas and international funding include calls for a better understanding of ecosystem functions (ESF) and ecosystem services (ESS). Ecosystem functions are defined as "the capacity of natural processes and components to provide the goods and services that satisfy human needs, directly or indirectly" (de Groot et al. 2002: 394). Thus, they represent interactions between biotic and abiotic components of ecosystems. Based on 'The Millenium Ecosystem Assessment' (2005) and subsequent summaries (e.g., Carpenter et al. 2009) three categories of ecosystem services can be identified: provisioning services, regulating services and cultural services. These ESS and ESF are exemplified for the Mahafaly Plateau in Table 1.

TABLE 1. Ecosystem services and ecosystem functions possibly relevant on the Mahafaly Plateau (modified from SuLaMa, unpubl. grant application to BMBF, Germany).

Service	Example	Ecosystem function
Provisioning Services		
Water supply	Drinking water for humans, livestock and wildlife, rainfed agriculture and irrigation	Run-off, infiltration, subterranean supply
Agricultural Crops and Fruit	Maize, manioc, sweet potatoes, beans, peanuts, vegetables, rice, papaya, mango	Food supply, nutrient suply and recycling, decomposition of soil organic matter
Wild crops/ fruit	Wild yams,	Biodiversity, food supply, provision of pharmaceutical components
	Diverse plants	
Alternative Fuel	Jatropha, Ricinus (castor oil)	Natural regeneration, restoration of degraded land
Domestic Meat	Large and small livestock	Primary production,
		water supply
Fauna diversity	Endemic species	Biodiversity
Wood	Fuelwood, construction	Biodiversity, biomass accumulation, carbon sequestration
Regulating Services		
Climate regulation	Microclimate in different forms of land use	Landatmosphere interaction
Pest and disease control	Food damage,	Natural selection
	Livestock parasites, Human diseases	
Cultural Services		
Culture	Sense of Place,	Biodiversity repositories for natural and degraded land
	Sacred forests	
Recreation	Eco-tourism	Aesthetic and intrinsic beauty, tranquillity

From the perspective of the natural sciences, there is a substantial discrepancy between the issues listed in Table 1 and the current and past research agenda in Madagascar. Madagascar has been (and still is) the 'promised land' for the description of new species (summarized at the time by contributors to Goodman and Benstead 2003). These exciting discoveries drew a lot of funding into the country. But research of ecological processes hardly exists. Instead, patterns of species distribution have been used to derive ecological and evolutionary processes. Doing so, we replace experimental proof by correlation. We simply have next to no information on very basic issues that are relevant for these ecosystem functions and services, such as nutrient cycling, multitrophic interactions, the reactions of ecosystems towards disturbances (fire, cyclones, landslides, pest outbreaks) or simply the reaction of endemic flora and fauna towards anthropogenic habitats, not to mention mycorrhizae or soil microbiology (du Toit et al. 2004, Suding and Hobbs 2008, Reiss et al. 2009, Chapin III et al. 2009, Gardner 2009, Irwin et al. 2010).

While research in the natural sciences can follow the beaten paths and many issues will not be too difficult to analyze with a standard methodology, the existing knowledge of the natural ecosystem properties, socio-economic and cultural aspects are by far more complex and difficult to integrate into a comprehensive development scenario, that, despite all efforts, remains to be heavily influenced by our western thinking of values and needs. There, the key to success is mutual trust and personal respect. Both can only be achieved through long-term commitment by people who work with people (Sayer 2009); otherwise trust and respect are replaced by financial bonds and falter as soon as the money comes to an end. It takes years to really understand the mentality and needs of the local people. This can not be achieved on a two year contract.

Along the same line of argument, funding agencies might consider (or even request) to fund research that combines the social and natural science approaches. For the time being, this is simply hindered by the formal review process of applications because there are not enough people who can review interdisciplinary applications like this. Based on past experience, most researchers in the natural sciences and social sciences have had tremendous problems understanding each other. Certainly, this problem is amplified when researchers (foreigners as well as nationals) try to communicate with local people. While this is the case, we can not really expect progress in a field that needs to combine understanding of people and nature. The only solution can be provided by close collaborations between social and natural scientists, integrated in joint conservation and development activities.

CONCLUSIONS

This Spotlights contribution started with the perception that neither conservation nor development activities achieve what they intend to achieve. This is not a Malagasy phenomenon but seems to be the reality in most parts of the world where economic and biodiversity interests act in various combinations. Poverty and subsistence cultures without alternatives in a growing human population, as well as wealthy people in power and foreigners with preconceived agendas, aggravate the problem.

Social and environmental problems can not be addressed separately. From the social perspective, natural resource management has been too focused on conservation without considering the specific needs and constraints of the people who were affected by the conservation activities. From the natural science perspective, the social proponents could not make clear how comprehensive considerations of the specific local experiences would contribute to sustainable utilization of natural resources if traditional land use management evidently failed in view of a rapidly growing human population. While these considerations are not new and the insight, that Integrated Conservation and Development Projects often did not achieve what they set out to achieve, has been described in detail (Sayer 2009), integrated action as the most likely solution to this dilemma is still not implemented routinely. While it would be presumptuous to claim to be able to provide advice on how to solve this problem, there may be some ideas on how the situation could be improved. From a natural research perspective, possible steps in this direction might include:

- Most importantly: Improve communication at all levels.
- Request integrated research, but more importantly, integrated action from natural and social sciences.
- Create open access regional or a national database(s): Here, data collected by various research and development projects are stored, can be analyzed and made available to other projects.
- Implement external, interdisciplinary review of research, conservation and development projects: Organizations and people have to admit that they can make mistakes as we all do; learn from mistakes instead of hiding them. These mistakes should not be used for negative publicity but to allow others to benefit from previous experiences.
- Supplement taxonomic research by research on ecosystem processes.
- Supplement natural research in pristine ecosystems by research in disturbed systems that will define the ecological tolerance of species and their capacity to adapt to anthropogenic habitats.
- Embark on the planning of a comprehensive network of utilization, restoration and conservation activities that will result in a mosaic of land use forms and habitat connectivity on a regional and possibly national level.

With these considerations for long-term perspectives in mind, we should work towards a system that is based on reliable and sustainable economic benefits and thus build a network that is resilient to short-term natural disturbances, but also to mid-term political perturbations, and its associated changes in international engagements.

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SHORT NOTE

Bats roosting in public buildings: A preliminary assessment from Moramanga, eastern Madagascar

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ABSTRACT

Madagascar has many synanthropic bat species but relatively little is known about how people interact with them. A preliminary assessment on the presence of bats in buildings and their interactions with people was conducted in the eastern town of Moramanga. Fifty of the 156 buildings were reported to contain active bat colonies and 46 of these were in schools. The bats, two species of Molossidae, roosted principally in the roof spaces of buildings that were more than ten years old. Users of the buildings were relatively tolerant of the bats, although 41% reported negative attitudes because of the odor of roosting colonies and some concerns over the possibility of contracting respiratory ailments from bat faeces. Guano accumulated in classrooms and was observed on floors and desks. Basic renovations could improve the learning environment for children and could be conducted in a bat-friendly way. More research is needed to assess the health risks to people from interacting with bats in Madagascar, and this includes people who study, eat, and handle bats or work and live in buildings or caves where bats roost.

RÉSUMÉ

Certaines espèces de chauves-souris ont su s'adapter à l'environnement humain et ont ainsi colonisé certaines parties des constructions humaines. Pourtant, de nombreuses espèces de chauves-souris sont associées à certaines maladies émergeantes. Madagascar possède plusieurs espèces synanthropiques de chauves-souris dont quelques unes associées à des virus alors que l'interaction de ces animaux avec les gens est très peu connue. Pour mieux comprendre ce phénomène, nous avons mené une étude préliminaire sur la présence de chauves-souris et de leurs interactions avec les gens dans des constructions urbaines, plus particulièrement dans des bâtiments publics (ceux de l'éducation ou de la santé) à Moramanga, une ville située dans la partie orientale de l'île. Des enquêtes informelles ont été réalisées auprès des usagers de ces enceintes et des comptages nocturnes de chauves-souris ont été effectués pour certains de ces bâtiments au moment où ces animaux quittaient leur dortoir. Les chauves-souris ont été identifiées grâce à des photos ainsi qu'à partir de mesures et caractéristiques morphométriques des individus capturés à l'aide de filets fauchoirs. Nous avons étalé des films en plastique pour récolter les fèces de chauves-souris dans les combles ou dans des salles de classes, et nous avons également recueilli les guanos amassés après le nettoyage des salles de classe. Les fèces ont été pesées avec des Pesola. Sur les 156 constructions répertoriées, une cinquantaine était habitée par des chauves-souris. La présence de ces animaux a été confirmée dans la plupart des écoles visitées (46 sur 65) mais pas dans les bâtiments hospitaliers et les centres médicaux. Les chauves-souris représentées par deux espèces de Molossidae, vivaient dans des combles de bâtiments publics construits depuis plus de dix ans. Les personnes utilisant ces bâtiments étaient relativement tolérantes sur la présence des chauves-souris bien que 41% relevait des attitudes négatives portant soit sur l'odeur dégagée par les colonies, soit sur des affections respiratoires attribuées aux fèces de ces chauves-souris, de sorte que certains occupants de ces bâtiments publics ont essayé, mais en vain, de se débarrasser de ces animaux. Les matières fécales s'accumulaient dans les salles de classe et ont été observées sur le sol et les bureaux. Des réparations élémentaires pourraient améliorer l'environnement éducatif pour les enfants et pourraient être conduites de manière à ne pas menacer les chauves-souris. Des recherches supplémentaires sont nécessaires pour évaluer les risques sanitaires des interactions avec les chauves-souris à Madagascar, et plus particulièrement pour les gens qui étudient, consomment ou touchent les chauves-souris, et même ceux qui travaillent ou vivent dans des immeubles ou des grottes où les chauves-souris gîtent.

KEY-WORDS: Madagascar, Moramanga, building, bats, health.
MOTS CLEFS : Madagascar, Moramanga, bâtiments, chauves-souris, santé.

INTRODUCTION

World wide, bats of many species live synanthropically in urban areas using human-made structures such as houses,

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schools, offices and bridges for roosting during the day (Kunz and Lumsden 2005). Bats are known in different parts of the world as vectors of certain pathogens, including the rabies virus (Messenger et al. 2005, Schneider et al. 2009) and the fungus *Histoplasma capsulatum*, which can develop on bat faeces under particular conditions (Lewis 1989, Gugnani and Muotoe-Okafor 1997, Taylor et al. 1999). Additionally, there is evidence that bats in some regions may serve as reservoirs of other viruses such as, or closely related to, Severe Acute Respiratory Syndrome coronavirus (SARS), Hendra, Nipah, Marburg, Ebola, and Tioman (Breed et al. 2006, Calisher et al. 2006, Wong et al. 2007, Yaiw et al. 2007). Thus, there is a potential risk of disease transmission when people are in close or regular contact with bats and this is an area of research that requires more attention.

In Madagascar, synanthropic species belong to the Emballonuridae, Molossidae and Vespertilionidae (Peterson et al. 1995, Goodman and Cardiff 2004, Goodman et al. 2005, Ratrimomanarivo and Goodman 2005, Andrianaivoarivelo et al. 2006, Rakotonandrasana and Goodman 2007, Goodman et al. 2008). Research has so far tended to focus on taxonomy and ecology and little is known about the interactions between people and bats, despite the apparent high occupancy rate of theses species in certain types of buildings (Ratrimomanarivo et al. 2007, 2009). Some Malagasy bats, however, are known to be associated with pathogens including haemoparasites, and viruses (Raharimanga et al. 2003, Rousset and Andrianarivelo 2003, Iehlé et al. 2007). A short survey of buildings in Moramanga, eastern Madagascar, was therefore conducted to assess the occurrence of bats roosting in public buildings and to obtain some preliminary data on guano accumulation. Information on the perception of people towards bats was also collected.

METHODS

The study was conducted in Moramanga, an urban commune in the Alaotra Mangoro Region with about 30,000 inhabitants, in eastern Madagascar (E48°13'45", S18°56'50") during November 2008. Local offices of the *Ministère de l'Enseignement National et de la Recherche Scientifique* – Ministry of National Education and Scientific Research (MENRS), *Ministère de l'Environnement et des Forêts* – Ministry of Environment and Forests (MEF), and *Ministère de la Santé et du Planning Familial* – Ministry of Health and Family Planning (MSPF) were visited to obtain information on the location of public buildings. Because of the potential health risk from bat faeces the survey focused on schools and hospitals and 26 locations were visited in total. Directors at each location were questioned about the construction history of the buildings and about the presence of bats. Information on the construction materials and architecture of each building were also noted.

At dusk, around 1800h-1930h, two or three people were positioned at key locations around the building from where they counted bats with hand counters. Bats were counted as they emerged from roosts in nine buildings. Species were identified from photos of roosting bats or individuals caught in hand nets as they emerged from the roost. Morphometric measurements (weight, length of forearm), pelage color and additional morphological characteristics were then used to identify the species (Peterson et al. 1995). Trapping and emergence counts were not conducted systematically at all sites. Statistical assessments of occupancy were not undertaken because buildings were not selected randomly.

Three plastic sheets (1 m x 4 m each) were placed in the attic of three buildings, directly under the roosting bats, and on the floor of one building where faeces accumulated to investigate the deposition rate of faeces. These plastic sheets were placed and removed by people familiar with the building and who periodically enter the attic to remove guano. In another four buildings, the routine of school children includes sweeping the floor clean of bat faeces each morning and the swept deposits were kept for later collection when the faecal pellets were removed by two of the authors (NR and AH). The guano collections were later weighed using a 10 g Pesola scale (accuracy ± 0.3 %) and the deposition rate per day was calculated for each square meter when plastic sheets were used. To assess people's perception of the bats, open informal interviews were conducted with 27 individuals who managed and worked in the buildings to ascertain if they considered the bats a nuisance or problem.

RESULTS

A total of 156 buildings were visited, of which 50 housed bat colonies. Bats inhabited 46 of the 65 school buildings surveyed. Fewer hospital buildings and medical centres were occupied by bats (Table 1). Roofing material was metal in all but one of the buildings surveyed. Walls of the buildings surveyed were mostly constructed of bricks or bamboo and mud, with 35 % and 31 % of such buildings occupied by bats, respectively (Table 1). Ceilings were either absent or constructed from wood, bamboo and mud or plastic. The occupancy rate of buildings with hardboard ceilings was the highest (Table 2). Buildings less than 10 years old did not contain roosting bats.

Evening counts yielded estimates of emerging bats that varied between two and 262 (66.1 ± 81.3 SD; n = 9). Two bat species were identified during the survey: Peter's wrinkle-lipped bat (*Mormopterus jugularis*) and Little free-tailed bat (*Chaerephon pumilus*), both of which are Least Concern on the

TABLE 1. Fifty public buildings were occupied by bats in the eastern town of Moramanga in Madagascar. Schools with brick walls and wooden ceilings were frequently used by bats.

Building type	Total	With bats	Without bats	% Occupancy
Primary school	74	18	56	24.3
Secondary school	15	8	7	53.3
High school	22	20	2	90.9
Hospital	27	2	25	7.4
Medical centre	4	0	4	0.0
Other	14	2	12	14.3
Construction materials				
Walls				
Brick (with cement layer)	118	41	77	34.7
Concrete	1	0	1	0.0
Bamboo and mud	29	9	20	31.0
Wood	8	0	8	0.0
Ceilings				
None	53	10	43	18.9
Hardboard	46	26	20	56.5
Timber	50	10	40	20.0
Bamboo and mud	1	1	0	100.0
Plastic	3	3	0	100.0
Unknown	3	0	3	0.0

TABLE 2. Bat faeces accumulated on ceilings and directly on the floor of classrooms in Moramaga (EPP: Primary School; CEG: High school; Lycée: Secondary school).

Locations	Days (n)	Method	Sampling surface area (m2)	Total mass of faeces collected (g)
Attic				
Ministry of Environment and Forests	2	Ceiling/sheet	12	0.5
CEG Moramanga Ambony	2	Ceiling/sheet	12	4.5
Lycée Razafindrabe Victorian	2	Ceiling/sheet	12	6
Room				
EPP Moramanga Ambony	3	Floor/sweeping	n/a	6
EPP Tsaralàlana	2	Floor/sweeping	n/a	0.02
EPP Ankazobe	3	Floor/sweeping	n/a	6.3
Lycée Technique	4	Floor/sheet	12	2.7
Lycée Razafindrabe Victorian	1	Floor/sweeping	n/a	0.5

IUCN Red List of Threatened Species (Andriafidison et al. 2008, Mickleburgh et al. 2008). Guano collection in the attics accumulated at 1.83 g ± 1.42 SD per day. In the buildings where faecal accumulation in rooms was measured, up to 2.0 g per day was collected. If deposition rates were consistent throughout the year, this equates to a maximum of about 0.7 kg of bat faeces per classroom.

Twelve of 27 interviewees from 10 buildings indicated that the presence of bats was a concern. Health and hygiene was the most commonly cited concern (n = 9), followed by building deterioration putatively caused by accumulated faecal and urinary matter (n = 3). Health complaints attributed to the bats by the interviewees were mainly 'flu-like infection' or 'sore throats', as well as indisposition caused by the smell. The director of one school reported that sacks of guano were collected from the attic space of one building when the roof and the ceiling were renovated in 2004. The guano was used as fertilizer. In four buildings, the occupants tried unsuccessfully to exterminate or to exclude bats from buildings by using pesticides or by sealing entrance holes.

DISCUSSION

Two species of molossid bats roosted in the public buildings (mainly schools) in Moramanga. The sampling of bats in this study was incomplete and, as other synanthropic species are known from the area, it is likely that other bat species were also roosting in the buildings (Andrianaivoarivelo et al. 2006). Also, because the sampling was biased towards public buildings and no information on bat presence was collected from private homes, shops or factories, the results in this study pertain only to the sample of buildings visited and are not more widely representative of urban areas in Moramanga.

Molossid bats in Madagascar are generally cave or crevice-dwellers but have made use of the roosting opportunities available in man-made structures (Ratrimomanarivo et al. 2007, 2009). *Mormopterus jugularis* is frequently found roosting in civic or municipal buildings, such as schools and offices, which were mainly constructed in the French colonial architectural style that features a suspended ceiling and aeration holes through which the bats gain access (Racey et al. 2010). In this study, occupancy rates were high in brick buildings older than ten years that had a hardboard ceiling.

Classical (*Histoplasma capsulatum*) and African histoplasmosis (*Histoplasma capsulatum var. duboisii*) are associated with bats and both have been recorded in Madagascar (Gugnani 2000, Rakotoarivelo et al. 2010). The extent to which a bat colony poses a health risk is dependent on disease incidence in the colony and on the frequency and closeness of contact with humans. Guano accumulates more frequently under weak or damaged ceilings and buildings that are poorly maintained present increased risk of exposure to, or contact with, bat faeces. In some schools the pupils were expected to clean the nightly faecal deposits as part of their daily routine. The accumulation of guano in classrooms might pose a health risk through the inhalation of, or contact with, fungal spores and this is a key area of public health research in the future. Simple repairs to the existing ceilings might quickly reduce the faecal-fall in the classrooms. Excluding bats from the buildings when they are away from the roost is also possible, but more challenging because they use multiple exit holes. The regular removal of faecal deposits in attics that can be safely accessed by people wearing respirators could also reduce the health risk to the human occupants and provide fertilizer for local use. Bat guano is marketed commercially in Madagascar from natural deposits and smaller scale enterprises from colonies in buildings may meet local demand in the future.

There is no clear procedure or legislation for dealing with unwanted bat colonies in Madagascar. Bats are frequently eaten by people in Madagascar (Jenkins and Racey 2008, Goodman et al. 2008), and can be legally hunted outside of strict nature reserves because they are classed as game (*gibier*) species in Malagasy law (Durbin 2007). Although legal provisions exist for issueing culling permits on a case-by-case basis for species that are dangerous to people or damage livelihoods, there is no provision for circumstances where the animals could be of a non-lethal public health concern.

Molossid bats in colonies in Madagascar frequently number in the hundreds and are found in both rural and urban settings, but local people rarely persecute these bats. There are no published accounts of bats culls in Madagascar and even when molossids are killed it appears to be primarily for food (Goodman et al. 2008). In Moramanga, a low frequency of anti-bat sentiment was reported by people, which suggests that, whilst the bats are unlikely to be popular, they are not yet considered a serious menace or a suitable source of protein. Direct contact between bats and people in Madagascar is low except for certain groups, such as people who trap, prepare or eat bats. Exposure to molossid faeces, however, is common in

public buildings in Moramanga and probably also other towns in Madagascar. Disease prevalence in molossids and the risk posed from exposure to bat guano in Madagascar is relatively unknown and should therefore be an area of research in the future.

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ARTICLE

Swarming behaviour and mass occurrences in the world's largest giant pill-millipede species, *Zoosphaerium neptunus*, on Madagascar and its implication for conservation efforts (Diplopoda: Sphaerotheriida)

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ABSTRACT

The first records of mass occurrences (swarming behaviour) in giant pill-millipedes, order Sphaerotheriida, are reported from Madagascar. Swarming behaviour in the order Sphaerotheriida seems to be restricted to a single of more than sixty described Malagasy species, *Zoosphaerium neptunus* (Butler, 1872), which is the world's largest known giant pill-millipede. Rolled-up individuals can be up to the size of a baseball, tennis ball or small orange, but only females reach this giant size, males being smaller than a ping-pong ball. Nine occurrences of such *Z. neptunus* swarms were analyzed based on actual specimens, video or photographic evidence collected by other researchers, dating back as far as 1892. One additional swarm, comprising several thousand individuals was examined in detail, with 260 randomly collected specimens being dissected and measured. The findings highlight that the swarming behaviour in *Z. neptunus* differs from that of all other millipedes in two important details: (1) The individual swarm is restricted to specimens of a single related size (and presumably age) class; often only sexually immature individuals; (2) the swarming behaviour is obligate, most, if not all specimens of the species in a given area participate in such swarms; *Z. neptunus* specimens are rarely, if ever, not found in a swarm. Reasons behind such massing events in millipedes are currently little understood, but a potential explanation for the mass occurrences in *Z. neptunus* might be higher survival rate from predation in combination with a close sibling relationship between members of one swarm. The almost obligate swarming behaviour in the widespread *Z. neptunus* species might represent a conservation problem, since whole swarms, and therefore a whole generation in a given area, can be lost through anthropogenic interferences such as over-collecting for the pet trade, habitat fragmentation or road kills.

RÉSUMÉ

Il est rare que l'Homme se retrouve au contact des myriapodes et plus rare encore que de cette rencontre naisse un antagonisme. On peut citer le cas du mille-pattes indien *Xenobolus carnifex* qui dégrade les toits et celui des essaimages de myriapodes qui entraînent souvent de graves problèmes dont le plus courant est l'invasion de maisons, voire de villages entiers. Ce comportement inhabituel est surtout mentionné pour l'Europe et les raisons de ce grégarisme chez les mille-pattes sont encore peu comprises. Certains pensent que ces rassemblements sont liés à la surpopulation ou qu'ils augmentent l'efficacité des défenses chimiques. Une des rares similitudes entre ces phénomènes est que les spécimens y participant sont adultes ou subadultes, jamais juvéniles.

Cet article fait état de la première observation d'un regroupement en masse (comportement grégaire) chez les grands mille-pattes volveurs, ordre des Sphaerotheriida, à Madagascar. Au sein de cet ordre, le comportement grégaire semble se limiter à une seule espèce parmi plus de soixante espèces malgaches connues, *Zoosphaerium neptunus* (Butler, 1872), actuellement l'espèce la plus grande des mille-pattes volveurs connus. Enroulés, des spécimens peuvent atteindre la taille d'une balle de base-ball, de tennis, ou d'une petite orange ; mais cela ne concerne que les femelles, les mâles étant plus petits qu'une balle de ping-pong. Notre étude se fonde sur l'analyse de neuf cas d'un tel grégarisme chez *Z. neptunus*, soit à partir d'observations directes, soit à partir de documents, notamment photographiques ou vidéo, recueillis par d'autres chercheurs, et ce aussi loin que 1892. Nous avons examiné en détail un essaim composé de plusieurs milliers de spécimens, dont 260 récoltés au hasard, disséqués et mesurés. Les résultats mettent en évidence que le comportement grégaire de *Z. neptunus* diffère de celui des autres mille-pattes sur deux points importants : (1) chaque essaim ne comporte que des spécimens de taille proche (et probablement d'un âge similaire), souvent exclusivement des spécimens immatures sexuellement ; (2) le comportement grégaire est obligatoire ; la plupart, si ce n'est tous les spécimens de l'espèce d'une zone donnée participent à ce genre d'essaimages, - *Z. neptunus* est rarement, sinon jamais, observé hors d'un essaim. On ignore les causes du grégarisme chez les mille-pattes, mais une explication possible du regroupement en masse chez *Z. neptunus* pourrait être un

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meilleur taux de survie face à la prédation en combinaison avec une relation fraternelle renforcée entre les membres d'un même essaim. Le comportement grégaire quasi-obligatoire chez le très répandu *Z. neptunus* pourrait compliquer sa préservation du fait que les interférences humaines telles que sa surexploitation à des fins commerciales, la fragmentation de son habitat ou le risque de mourir sur la route peuvent entraîner la perte d'essaims entiers, et donc de toute une génération dans une zone donnée.

KEY-WORDS: Swarming behaviour, millipede, island gigantism.
MOTS CLEFS : grégaire, mille-pattes, gigantisme insulaire.

INTRODUCTION

There are few situations when humans come into contact with millipedes, and even fewer which result in man-millipede conflict. Among the most fascinating are, aside the roof-eating behaviour of the Indian millipede *Xenobolus carnifex* (Alagesan and Muthukrishnan 2006), millipede swarms. Those millipede swarms are fascinating situations, often resulting in serious problems. The oldest record of such an event is from Theophrastus who reported that a millipede swarm drove the inhabitants of Rhoeteum, a village located in present day Turkey, into the sea (Sharples 1994). Fossil findings of millipede swarms date back to the Upper Carboniferous (Wilson 2006). In present times, the occurrence of swarming millipedes can cause situations as serious as derailed trains (Verhoeff 1900); these events resulted in the common Japanese name 'Train Millipede' for a species involved into such accidents (Niijima 2001). More common are invaded houses (Voigtländer 2005) or whole German villages (Lee 2008). In 2007, a wall had to be built around the German city of Obereichstätt to keep the millipedes out (Enghoff and Kebapci 2008). Most records of this unusual behaviour are from Europe (Ehrnsberger 2002, Voigtländer 2005). The reasons for this swarming behaviour in millipedes are still little understood. One of the few similarities between the events is that participating individuals are adults or sub-adults, never juveniles (with the exception of some juvenile Polydesmida (Lewis 1971), which stay together in a swarm after hatching but don't migrate). In case of the fossil swarming millipedes, it was suggested that agglomeration increases the efficiency of chemical defenses in millipedes (Wilson 2006).

While for numerous millipede orders records of such unusual events exist (summary in Voigtländer 2005), nothing was previously known about swarming in giant pill-millipedes, order Sphaerotheriida, or any other millipede species occurring on Madagascar. The giant pill-millipedes on Madagascar, members of the Malagasy-Indian family Arthrosphaeridae (Wesener and VandenSpiegel 2009), belong because of their island gigantism (Wesener 2009) to the most astonishing invertebrates of the world's third largest island. Some species of the endemic genus *Zoosphaerium* are much larger than giant pill-millipedes from other areas. Fully grown individuals reach, when rolled-up, the size of a baseball (Wesener and Wägele 2008), while the largest species from South Africa and India only reach the size of a ping-pong ball (VandenSpiegel et al. 2002).

The world's largest described giant pill-millipede species is *Zoosphaerium neptunus* (Butler 1872), also called 'Emerald-Green Giant Pill-Millipede' because of its shiny green colour (Figure 1), where adult females can reach a gigantic size of

FIGURE 1. The 'Madagascar Green-Emerald Giant Pill-Millipede', *Zoosphaerium neptunus* (Butler, 1872). Juvenile individual, approximately 30 mm long, photographed at Andasibe.

90 mm. *Z. neptunus* is in many aspects quite an unusual giant pill-millipede species; firstly because the species is one of the few widely distributed on Madagascar (Figure 2), and secondly because the males are much smaller than the females, reaching only up to 45 mm in length. In fact, because of their size difference, males were even described as a separate species, *Sphaerotherium digitale* (see Wesener and Wägele 2008).

On Madagascar, species of giant pill-millipedes are rarely found in large aggregations. Collectors usually only find as many as five up to ten individuals in the same spot (own experiences). The first report dealing with large aggregations of giant pill-millipedes on Madagascar are more than a century old and came from the English missionary James Sibree. He mentioned in his book (Sibree 1915:159-160, but observation made 1892): "In passing along the forest paths we frequently come across

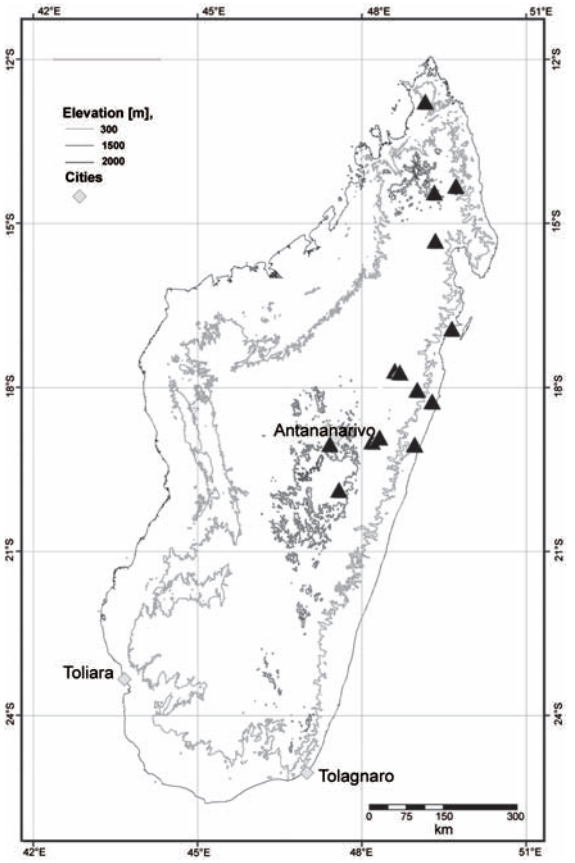

FIGURE 2. Distribution map of *Zoosphaerium neptunus* (Butler, 1872). Points are mapped after published records in the literature (Wesener and Wägele 2008, Wesener et al. 2010).

examples of the curious ball insect (Spherotherium [sic] sp.), of which there are several species, at least six, in Madagascar. These insects, which are wingless and many-footed, and are called, not very elegantly, by the Malagasy *Tainkìntana*, or 'Star-droppings', (...). In passing through the main forest in 1892, we came suddenly one day to a part of the road which was so thickly covered by such a great number of these creatures that our bearers could not avoid trampling on them. These were of a bronze-green tint and belong to a third species, and were quite three inches in length." For almost 100 years, such events were never mentioned again and all but forgotten by the scientific community, probably because of the lack of similar notions of giant pill-millipede swarms in the scientific literature.

To our own surprise, we literally stumbled upon a millipede swarm of *Zoosphaerium neptunus*, also called 'green-eyed monsters' by terraristic enthusiasts in the United States, in the summer of 2007 close to Andasibe (Périnet). The swarm contained small-sized individuals. Locals informed us that giant pill-millipede swarms can be regularly observed in the area.

METHODOLOGY

Night search was conducted for 15 man-hours in the natural forest at Andasibe. Swarm observations were made for two days. Weather conditions included light rain. Measurement of the length of the swarm was made with a Garmin Geko 201 GPS (accuracy +/- 8 m). Counting of the actual number of individuals was tried for 100 x 100 cm (unsuccessful because of too many specimens). Twenty times 10 x 10 cm were randomly chosen at different points of the swarm, and all individuals were counted. Observations of the behaviour were made, separating three major activities (walking, resting, and feeding). The walking direction of individuals was noted.

At 13 randomly chosen points, 20 specimens were randomly collected and stored in 85 % alcohol, altogether 260 specimens. An additional 13 deceased specimens were collected out of puddles. Three characteristics, body size (width of thoracic shield), sex, and development stage (sexually mature/immature) were recorded for all 273 specimens (see Supplementary Material). Sexes were separated based on the presence of two additional leg pairs on the posterior body end (telopods) in males. Juveniles were identified as not possessing the full number of tergites (12 + anal shield) or legs (21 in females, 23 in males), while specimens were identified as immatures using the following characters: (1) Females, non-sclerotized plates of the female vulva; (2) Males, width of inner horns on posterior telopods (see also Wesener and Sierwald 2005).

RESULTS

REPORTS OF GIANT PILL-MILLIPEDE SWARMS. Discussions with co-workers, and correspondence with other scientists conducting field work on Madagascar yielded additional unpublished records of swarming behaviour. Furthermore, sorting out millipedes in a museum collection also produced further evidence for a giant pill-millipede swarm on Madagascar. Additional reports of giant pill-millipede swarms include:

(1) Written report (Sibree 1915), on way from Tamatave to Antananarivo, 1892, thousands of specimens. Length '3 inch', probably >70 mm.

(2) Collection vial at the Muséum National d'Histoire Naturelle, Paris, France dating from 1941 (Madagascar – R. Decary – Betampona – Réserve Naturelle N°1 – en Forêt – 28 mai 1941) contains more than 200 *Zoosphaerium neptunus*, a potential indication of a millipede swarm. All specimens are between 10-15 mm long and represent immatures.

(3) and (4) M. von Tschirnhaus and S. Gehring (Marojejy, 400-600 m in 2003 and 2006), photographic evidence, 'thousands of individuals'. Specimens approximately 30-40 mm long.

(5) A. Ballerio (Andasibe, 7 January 2006), photographic evidence. Specimens approximately 30-40 mm long.

(6) M. Helb in 2001, close to Andasibe, oral report (80 specimens in one square meter) with specimens (vouchers (60 mm long) stored at the Field Museum, FMNH-INS-55880).

(7) M. Vences, near Hevirina, Makira Plateau, 23 June 2009, video evidence, photographic evidence, specimens (vouchers (30 mm long) deposited at the Zoologische Staatsammlung Munich, ZCMV 11314). A video of the swarming was stored online under: <http://www.youtube.com/watch?v=DJ1Fw4caogE>

(8) J. Coddington, N. Scharff, S. Larcher, C. Griswold, R. Andriamasimanana, Parc National Montagne d›Ambre, 1,100 m, coll. 29 November 1993, specimens (vouchers (11-14 mm long), 18 immature specimens, stored at the Natural History Museum of Denmark, Copenhagen, Denmark, ZMUC 00101322).

(9) J. Coddington, N. Scharff, S. Larcher, C. Griswold, R. Andriamasimanana, Marojejy Reserve, 700 m, coll. 10-17 November 1993, specimens (vouchers (10-11.5 mm long), 24 immature specimens, stored at the Natural History Museum of Denmark, Copenhagen, Denmark, ZMUC 00101323).

ANALYSIS OF THE GIANT PILL-MILLIPEDE SWARMS. With the help of voucher specimens, precise photographs or video evidence, all the records could be determined to involve a single species, *Zoosphaerium neptunus*. During the night search inside the forest at Andasibe, a partially degraded rainforest, no specimen of *Z. neptunus* was found. All specimens of *Z. neptunus* discovered during this study were part of the swarm (Figure 3A). The length of the swarm was 1,100 m (accuracy +/- 16 meters), while its width varied between three and approximately 10 m. Counting or even an estimation of the number of specimens involved in the swarm was difficult because of the large differences in local densities. Many specimens were hidden in short grass. At least several ten thousand individuals participated in the swarming event. Most specimens were observed slowly walking, a few were feeding. Many dead specimens could be found along the trail. For every three specimens observed walking probably one was found dead, almost exclusively in a puddle. However, these are arbitrary numbers, since dead specimens were more likely to be seen than living specimens, which were often hidden in the grass. The bottom of the few puddles was in some cases covered with dead specimens (Figure 3B). In fact, specimens seemed to be almost oblivious to their surroundings, at least they showed no avoidance reaction to water, nor did they try to escape from it. Quite some individuals were observed walking directly into, and drowning in, a puddle. This observation can be confirmed by photographic

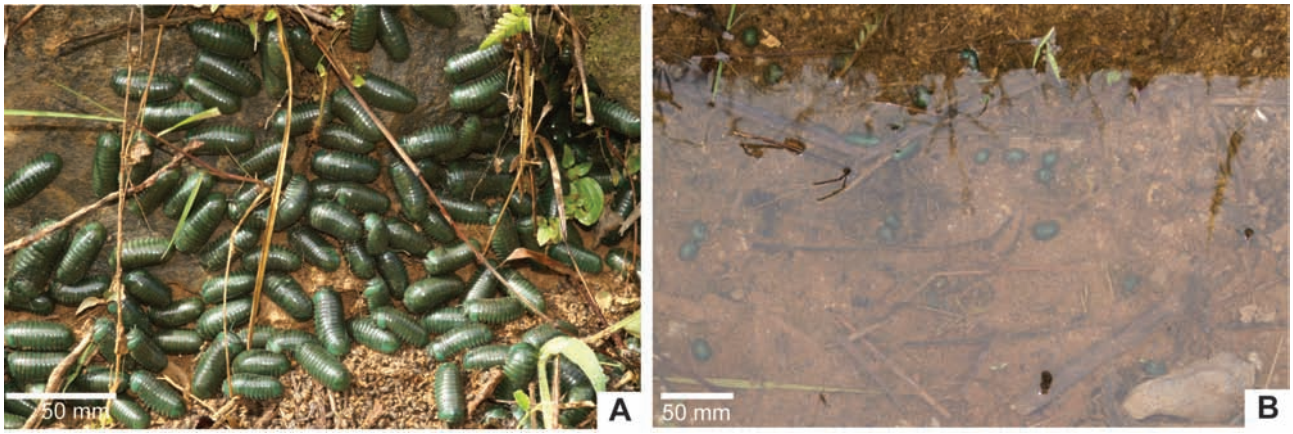

FIGURE 3. Millipede swarm of *Zoosphaerium neptunus* at Andasibe, Madagascar. A: Swarming individuals, B: Puddles along the swarm filled with drowned specimens.

evidence from Marojejy (Michael von Tschirnhaus and Sebastian Gehring 2006, see (3) and (4) in Results), where parts of a swarm walked into and drowned in a small river (Figure 4A).

No single specimen was observed walking 'against the current', all specimens were moving in the same direction (southeast), even when not in contact with one another. The path of the swarm was to the north barricaded by a railway track and a few meters further north by a river. Only very few specimens were observed in direct contact with the railway. Some individuals were also detected on the other side of the railway, closer to the river.

Of 273 randomly collected individuals, 105 were males, while 168 were females. The males were 8.3-14.1 mm wide (average width 10.4 mm). According to the inner horns of the posterior telopods (Wesener and Sierwald 2005), all males were sexually mature. The females were 9.95-15.4 mm wide (average width 11.4 mm). All females displayed non-sclerotized vulvae and were sexually immature.

DISCUSSION

The collected evidence indicates a remarkable observation: The millipede swarms of *Zoosphaerium neptunus* contain individuals of similar body size, and therefore presumably development stage. Most of the swarms seem to contain small to medium-sized specimens, while the swarm observed by M. Helb contained mature individuals with 60 mm body length, and it appears that Sibree (1915) surveyed a swarm of fully grown specimens (>7 cm). There is one eminent difference between the swarming behaviour of *Z. neptunus* and such events observed in other millipede groups (Voigtländer 2005): Even immature individuals of *Z. neptunus* form swarms. The only other described cases of juvenile millipedes forming aggregations are restricted to the order Polydesmida. Here, juveniles of some species often remain in feeding flocks, those 'swarms' never leave the soil nor show migration tendencies (Lewis 1971).

During swarming, *Zoosphaerium neptunus* individuals pay little attention to their surroundings; many specimens were observed walking straight into and drowning in small puddles. Some swarms even display 'cliché lemming behaviour', in Marojejy, a large part of a swarm walked into and drowned in a small river (Figure 4A).

Since no individuals of *Zoosphaerium neptunus* were found in the adjacent pristine rainforest, despite intense searching and ideal 'millipede' weather (wet leaf litter, slight rain), it is unlikely

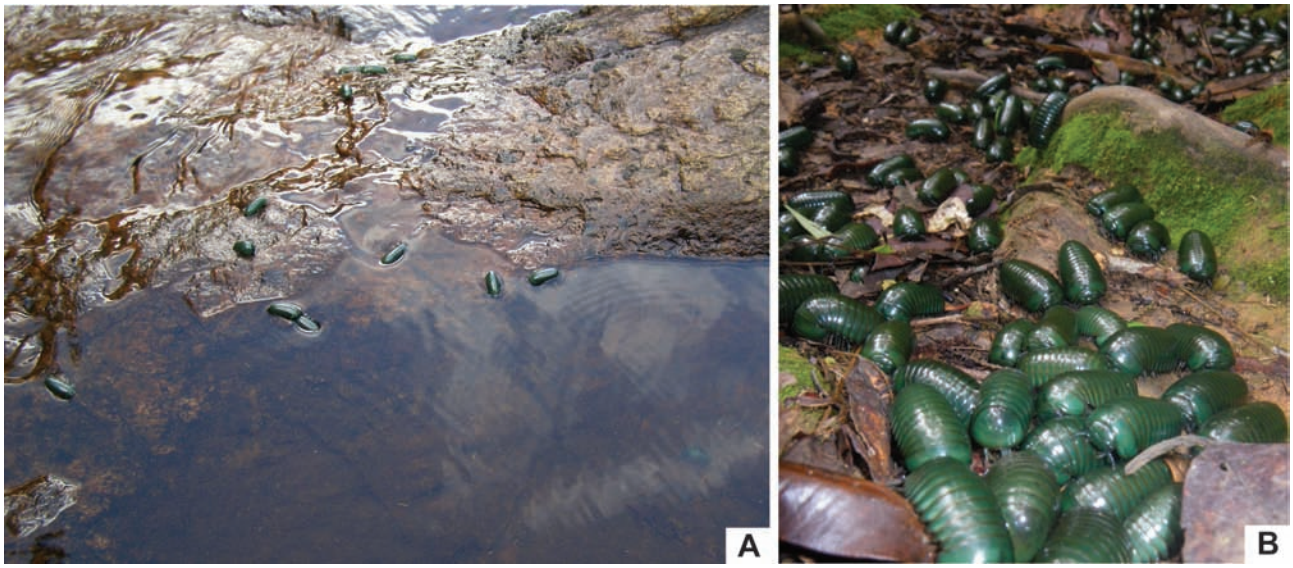

FIGURE 4. *Zoosphaerium neptunus* millipede swarms. A: Parts of the swarm walking into a small river at Marojejy 2006 (Photo courtesy of M. von Tschirnhaus); B: Swarm at Makira 2009, individuals circa 30–40 mm long (Photo courtesy of M. Vences).

that the swarming behaviour of *Z. neptunus* is correlated with migrations caused by unsuitable habitat or overpopulation. Based on the 10 independent observations of *Z. neptunus* agglomerations, it can be concluded that the swarming in *Z. neptunus* seems to be the norm and not the exception. The reasons for such swarming behaviour in giant pill-millipedes are currently unknown, but an analysis of the individuals of the Emerald-Green giant pill-millipede involved in such swarms allows several conclusions.

(1) Giant pill-millipedes from Madagascar possess unique stridulation organs in both sexes whose function is still little understood (Wesener and VandenSpiegel 2009). Our data, however, suggests that stridulation plays no major role in the formation of such swarms in *Zoosphaerium neptunus*, since the stridulation ribs in females of the species are very weakly developed (Wesener and Wägele 2008).

(2) Based on an agglomeration of a fossil millipede assemblage, authors (Wilson 2006) suggested that the accumulated poisonous defence components most millipedes possess leads to an overall survival benefit of all swarm members. While this might be true for most millipede swarms (it was suggested for agglomerations of juvenile polydesmids (Lewis 1971)), it cannot be applied to giant pill-millipedes, since they are the only large-bodied millipede order known which does not possess poisonous defence fluids (Wesener and VandenSpiegel 2009).

(3) Special mating practices can be excluded as an explanation, since our data clearly show that at least all females involved in the Andasibe swarm were sexually immature.

(4) We interpret such swarms as a defense strategy against predators (although it is still unknown which animals prey on giant pill-millipedes), which increases the survival chance of each member of the millipede 'herd'. The fact that the giant pill-millipedes rely on nearly unlimited food resources (leaf litter) might add further benefits to swarming behaviour. The similar size of the individuals inside the same swarm is conspicuous. The collected evidence suggests that those swarms comprise specimens of the same generation and same area. If the individuals in one swarm have a sibling relationship remains unknown, and should be analyzed in the future with molecular methods.

CONSERVATION

Swarming behaviour is a new conservation problem for giant pill-millipedes. Because of the high number (>30 %, Wesener 2009) of microendemic species, the conservation of small forest remnants should be given priority. However, millipedes like *Zoosphaerium neptunus*, which live in obligate swarms as part of their life cycle need a larger, non-fragmented area; such areas no longer exist in many parts of Madagascar. If large areas do not exist, the possibility is quite high that a whole swarm dies (and therefore a large amount of the whole *Z. neptunus* population in the area is gone). Swarms can come into contact with human-altered vegetation, like *Eucalyptus* plantations, fields or grasslands, which represents an unsuitable habitat for giant pill-millipedes (Wesener and Wägele 2007), or even roads, leading to a mass dying. The determination with which swarming individuals walked without hesitation into death traps such as puddles or even rivers are an indication of what would happen if these species came into contact with road traffic. The construction of large-scale pipelines (Rall et al. 2010) might therefore also impact the survival of this species.

Another possible threat for *Zoosphaerium neptunus* swarms are collections for the pet trade. There exists a large demand in Japan, Europe and North America for 'green-eyed monsters' as pets. Larger sized individuals are usually sold for Euro 15-20 in Germany. Giant pill-millipedes from Madagascar have unfortunately a very short survival time in terraria. The species is specialized on low-energy food (dead leaves), and adapted to the cool climates (<20°C) of the highlands. Specimens in terraria often starve to death quickly. While for most species it would be difficult, if not impossible to collect a large percentage of a population of giant pill-millipedes in a given area because of their cryptic habits, this cannot be said about *Z. neptunus*. A single large swarm might represent the whole generation, or a significant part of it in a given area, and harvesting a complete, or a large percentage of such a swarm might irreversibly harm the survival of a *Z. neptunus* population in the area.

Such harvesting therefore might require proper management. If a whole swarm is collected, the population of a large area could be lost at once. If only several hundred immature individuals are harvested, the impact on the population is potentially very small, since a large percentage of the swarm succumbs to obstacles like small puddles or rivers.

More studies are needed to assess the frequency of the swarming behaviour in the world's largest giant pill-millipede species, *Zoosphaerium neptunus*. This is something which can only be done by local researchers capable of tracking or observing swarms the whole year round.

With the help of such additional observations it might be possible to develop crucial conservation measures for the Malagasy Green Emerald giant pill-millipede *Zoosphaerium neptunus*, whose size makes it one of the most conspicuous mega-invertebrates of the island, and whose swarming behaviour is one of the most fascinating natural events observed in millipedes.

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ARTICLE

Abundance and conservation status of two newly described lemur species in northwestern Madagascar *(Microcebus danfossi, Lepilemur grewcockorum)*

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ABSTRACT

The distribution and abundance of Danfoss' mouse lemurs (*Microcebus danfossi)* and Grewcock's sportive lemurs *(Lepilemur grewcockorum),* two regional endemics from northwestern Madagascar, were studied from May to December 2008 in the Sofia region between the rivers Sofia and Maevarano. The goal was to investigate the size and quality of forest fragments and to determine the presence and abundance of the recently described *M. danfossi* and *L. grewcockorum*. They are confined to this region and their conservation status has not yet been determined. A total of eleven sites were visited and systematic census observations were carried out in each of them. *M. danfossi* was present in ten of eleven sites and its abundance ranged from 4.5 to 8.5 individuals per kilometer. *L. grewcockorum* was present in only three of eleven sites and its abundance ranged from 0.8 to one individual per kilometre. Based on the results of this study *M. danfossi* should be listed as Vulnerable and *L. grewcockorum* as Endangered. Based on the abundance data, the size and the general condition of the fragments, the forests of Anjajavy, Ambarijeby and Bekofafa are most favorable for future protection, because they still contain the most intact nocturnal lemur communities.

RÉSUMÉ

Une étude sur la distribution et l'abondance de *Microcebus danfossi* et *Lepilemur grewcockorum*, deux espèces endémiques de la région Nord-ouest de Madagascar, a été effectuée dans la région de Sofia, entre les fleuves Sofia et Maevarano, de mai à décembre 2008. Les objectifs étaient d'évaluer la qualité et la largeur des fragments forestiers restants ainsi que de déterminer la diversité de lémuriens nocturnes dans la région. Nous avons aussi prévu de détecter des sites potentiels en vue de la conservation de fragments présentant une biodiversité riche, en particulier en ce qui concerne les espèces de lémuriens nocturnes récemment décrites dans cette région, *M. danfossi* et *L. grewcockorum*. Enfin, nous avons récolté toutes les informations disponibles afin de proposer une classification objective pour chaque espèce conformément aux critères de l'IUCN. Nous avons inventorié onze sites au total, à savoir la forêt d'Anjajavy, le *savoka* du village d'Antonibe, la forêt d'Antambato, le *savoka* d'Antsatrana, la forêt de Beanamalao, la forêt de Betsatsika, la forêt d'Ambarijeby, la forêt d'Ankaramikely, la forêt de Bekofafa, les *savoka* d'Ambararata et de Mahadera. Dans chaque site de ces sites, nous avons évalué la qualité de la forêt (signe de feu, déboisement, trouées) et la surface du fragment avant de réaliser six inventaires nocturnes le long de deux pistes de 1 km de longueur. Nous avons identifié de deux à quatre espèces de lémuriens nocturnes par site et au total cinq espèces ont été recensées. *M. danfossi* était présent dans dix sites et son abondance variait de 4,5 à 8,5 individus par kilomètre. *L. grewcockorum* n'était présent que dans trois sites et son abondance variait de 0,8 à 1,0 individu par kilomètre. Les fragments avaient des superficies comprises entre 50 et 400 ha. Les forêts d'Anjajavy, d'Ankaramikely, d'Antambato et de Bekofafa se sont avérées être les meilleurs sites en matière de qualité de la forêt. Compte tenu du degré de fragmentation, des pressions anthropiques et de nos résultats d'inventaire de ces deux espèces endémiques, nous proposons un statut de conservation Vulnérable pour *M. danfossi* et En Danger pour *L. grewcockorum*. Nous proposons également de considérer la protection des forêts d'Anjajavy, d'Ambarijeby et de Bekofafa dans la mesure où elles sont encore intactes et abritent un assez grand nombre d'espèces de lémuriens.

KEYWORDS: Mouse lemur, distribution, fragmentation, primates, sportive lemur.
MOTS CLEFS : microcèbe, distribution, fragmentation, primates, lépilémur.

INTRODUCTION

Madagascar is considered one of the biodiversity hotspot countries due to its unique wildlife and to high levels of anthropogenic pressure on the island. Therefore, it is at the top of conservation priority lists worldwide (Myers et al. 2000). Lemurs are 100% endemic to Madagascar and with more than 95 extant species (Mittermeier et al. 2010), they represent the largest of only five extant mammalian orders present on the island. Lemurs are forest dependent and therefore particularly threatened by the

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dramatic degree of deforestation and habitat degradation on the island (Harper et al. 2007, Kremen et al. 2008). On the other hand, we still lack important datasets on the biology and distribution of many species, in particular on the nocturnal, cryptic taxa. This makes it extremely difficult to estimate their exact threat level and to formulate effective conservation strategies. More specifically, 42 of 92 lemur taxa (45.7 %), presently listed in the IUCN Red List (<www.redlist.org>), are categorized as 'data deficient'. This study aims to determine the conservation status of two of these species that belong to the lemur genera with the highest species richness, the nocturnal mouse lemurs (*Microcebus* spp.) and sportive lemurs (*Lepilemur* spp.).

Mouse lemurs are the smallest primates in the world. In early studies, only two species, *Microcebus murinus* and *M. rufus*, were described distinguished (Martin 1972). However, the diversity within the genus *Microcebus* is currently judged to be much higher (Mittermeier et al. 2008, Weisrock et al. 2010). Recent molecular, genetic, acoustic and morphological studies have resulted in an extraordinary increase in the number of recognized species with 16 further species having been described or resurrected within the last 16 years (Schmid and Kappeler 1994, Zimmermann et al. 1998, Rasoloarison et al. 2000, Yoder et al. 2000, Andriantompohavana et al. 2006, Louis et al. 2006a, Olivieri et al. 2007, Louis et al. 2008, Radespiel et al. 2008). However, we still lack information on the biology and distribution of most species which prevents a full evaluation of their conservation status.

Sportive lemurs *(Lepilemur* spp.) live in almost all remaining forest regions of Madagascar (Harcourt and Thornback 1990, Mittermeier et al. 2003). The species diversity within this genus as well as their distribution and conservation status is only poorly known (Mittermeier et al. 2003). Recent molecular taxonomic studies have shown that the species diversity in *Lepilemur* was also highly underestimated and the number of described species has increased to 25 over the years (Andriaholinirina et al. 2006, Louis et al. 2006b, Rabarivola et al. 2006, Craul et al. 2007, Lei et al. 2008).

Until recently, the mouse lemurs and the sportive lemurs of the Antsohihy region (area about 11,000 km^2 between the rivers Sofia and Maevarano) have been assigned to their close relatives and geographic neighbours to the south: *Microcebus ravelobensis* and *Lepilemur edwardsi*, respectively. In 2006 and 2007, however, two new nocturnal lemur species were described from this region, *M. danfossi* and *L. grewcockorum* (Louis et al. 2006a, Olivieri et al. 2007). They differ from their neighbouring congeners in 2-5 (*L. grewcockorum*) and 2-10 (*M. danfossi*) morphometric measurements (Craul et al. 2007, Olivieri et al. 2007). Furthermore, they have unique molecular diagnostic sites in the sequenced mitochondrial loci and have already clearly diverged on the molecular level from their geographic neighbours during their isolated evolutionary history (Louis et al. 2006b, Craul et al. 2007, Olivieri et al. 2007). Due to their very recent description, information on their distribution and abundance in northwestern Madagascar is still lacking. The forests in this region typically consist of relatively small forest fragments (1.5-37 km^2, Olivieri et al. 2008), which are disturbed by human activities such as illicit timber exploitation and/or poaching. Due to their very small geographic range and the rate of ongoing habitat loss and fragmentation in the area, it is critical to determine the distribution and abundance of the remaining populations. For this purpose, we collected data on the distribution and abundance of both newly described lemur species and on the presence of other nocturnal lemur species at eleven different locations in northwestern Madagascar. In addition, we estimated the amount of anthropogenic disturbance at each site in order to determine the actual conservation status of *M. danfossi* and *L. grewcockorum* and to develop recommendations for the future conservation of these two regional endemics.

METHODS

LOCALIZATION AND SELECTION OF STUDY SITES. Previous studies have suggested that the Sofia River and the Maevarano River limit the global distribution of both lemur species to the north and south, respectively (Olivieri et al. 2007, Craul et al. 2007). The field study was therefore conducted in 2008 at eleven sites between these two rivers. The sites varied in altitude from almost sea level (site 1) in the west to more than 1,700 m altitude (site 3) in the east (see Figure 1, Table 1). Study sites were chosen based on a combination of forest cover information from satellite imagery (Landsat, Google Earth). We aimed to visit large fragments, whenever possible, since our priority was to identify promising candidate forests for future conservation efforts.

ANTHROPOGENIC DISTURBANCE IN THE FOREST. Forest fragments were surveyed along two transects per site: Signs of anthropogenic disturbance were recorded as the amount of cut wood, traces of fire, and numbers of holes in the ground from extracting tubers. Anthropogenic disturbance was noted every 40 m within a 10 m radius along two 1 km trails where the census counts were also conducted. We used pre-existing trails for this study in order to avoid any study-induced habitat disturbances. Transect trails were straight and representative of the habitat. The degree of disturbance was expressed as the percentage of trail points showing disturbances. We calculated separately the average of all disturbances on each trail and then determined the average for two trails. Anthropogenic disturbance was considered 'low', if the percentage of affected points ranged between zero and 30 % (good condition), 'average' if ranging between 30 and 60 % (average condition) and 'strong' if greater than 60 % (bad condition). In addition, we walked along the border of the forest and took the GPS co-ordinates in order to estimate the size of the forest fragment either in the field or retrospectively with the help of satellite imagery.

CENSUS OBSERVATIONS. Two observers conducted one census per night together for three nights along each trail. The census observations were performed along a 1 km transect line, and began at about 1800h and lasted approximately 2 hours. During a census, both observers moved slowly to detect all the animals close to the transect line. One observer focused to the right side of the trail, the second to the left. Head lamps were used to locate the animals by their eye shine. Once an animal was visually detected, one observer noted all the parameters and the second followed the individual and identified the species using a strong flash light. Nocturnal species and genera were discriminated based on their overall size (sufficient for discrimination between *Microcebus* sp.*, Cheirogaleus* sp.*,* and *Lepilemur* sp.*/Avahi* sp.) and their head proportions (relative ear size and protrusion of snout differs between *Lepilemur* sp. and *Avahi* sp.). Each detection was recorded on a dictaphone

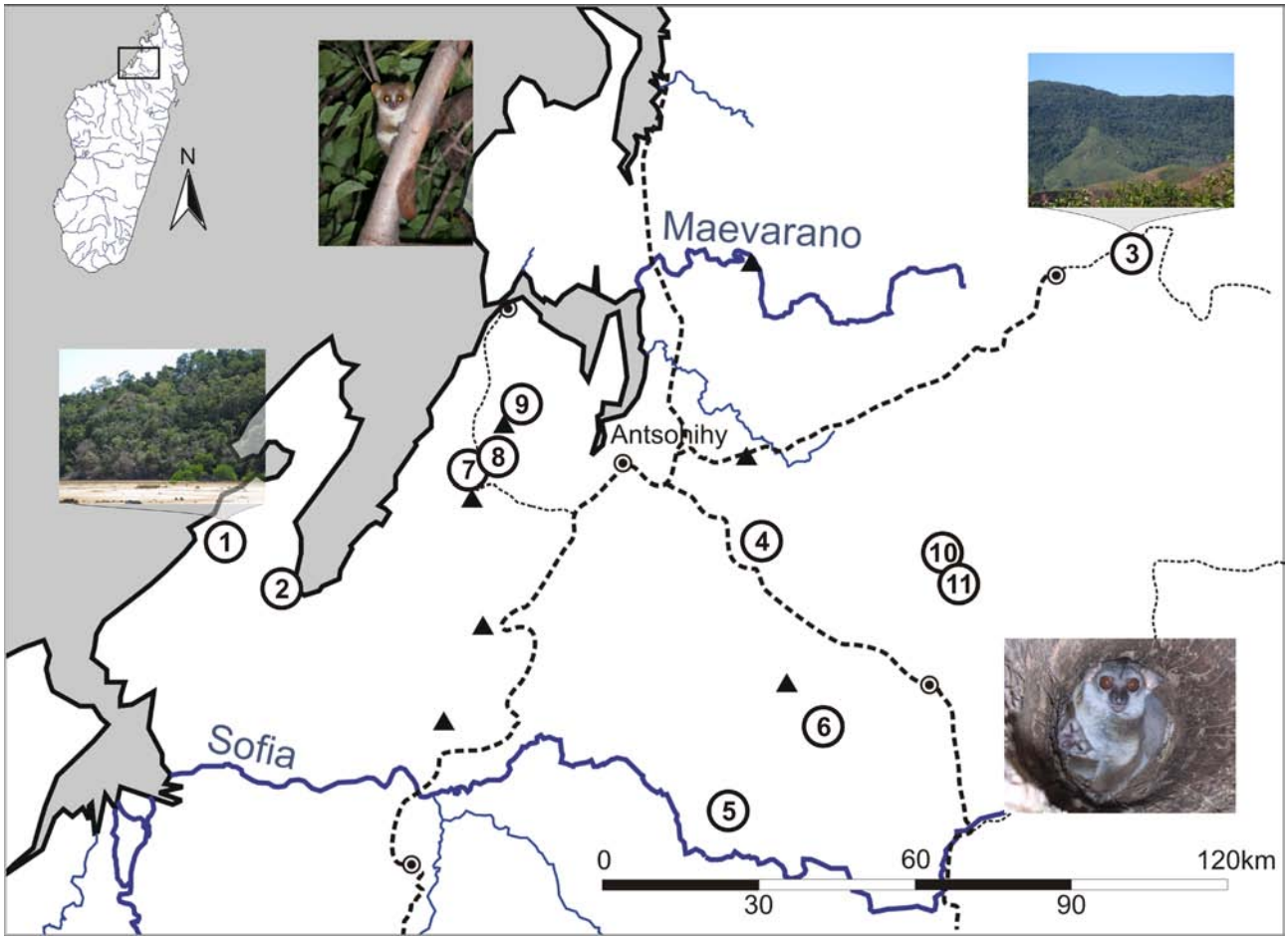

FIGURE 1. Map of northwestern Madagascar showing our study sites (numbered from 1-11) and the study sites of a previous study (Olivieri et al. 2005, black triangles), larger towns (black & white dots) and main roads (dashed lines) between the two rivers Sofia and Maevarano. The photos depict the easternmost (site 3, Antambato) and the westernmost (site 1, Anjajavy) site and the two regional endemics under study (*Microcebus danfossi* – left-upper corner, *Lepilemur grewcockorum* – right-lower corner). Photos were taken by B.R. (landscapes and *M. danfossi*) and by M. Craul (*L. grewcockorum*).

and the following parameters were noted: (i) direct distance between the observer and the animal, (ii) perpendicular distance between the animal and the trail, and (iii) the angle between the animal, the observer, and the trail.

ESTIMATION OF LEMUR ABUNDANCE. The composition of the nocturnal lemur communities at the study sites was obtained from the nocturnal census observations. The encounter rate, i.e. the number of individuals of *Microcebus danfossi* and *Lepilemur grewcockorum* observed per kilometer of census observation was determined for each census walk. Population densities could be estimated for *Microcebus* spp. only due to limited encounter frequencies for the other nocturnal species. Population densities of *Microcebus* spp. (Ñ / A) were estimated based on the census data by using the formula given by Müller et al. (2000): Ñ / A = ñ / (2 x l x w)

- Ñ: Number of individuals in the zone of census,
- A: Area of the zone of census,
- ñ: Average of the numbers of the individuals within *w,*
- *w*: Width of the field of detection on each side of the transect,
- l: Length of the transect.

All animals detected outside *w* were excluded (Müller et al. 2000); *w* was determined using histograms with distance classes, effectively partitioning all sightings of *Microcebus* spp. according to their perpendicular distances. The width *w* is defined as the distance where the number of detected individuals decreases by 1/3 or more compared to the preceding distance class. This upper limit of the distance class is the so-called 'fall-of-distance'. The width of detection is considered the same for both sides of the trail.

STATISTICAL ANALYSES. The relationship between fragment size and the level of anthropogenic disturbances was tested with an ANOVA (Type VI, sigma restricted). The relationships between the number of nocturnal lemur species, the

TABLE 1. Geographical coordinates, altitude, and survey month of the study sites.

Site no.	Site	Coordinates	Altitude	Month
1	Anjajavy	S15°01'39.6" E47°16'38.4"	25 m	May
2	Antonibe	S15°06'14.6" E47°22'42.1"	44 m	May
3	Antambato	S14°30'38.3" E48°52'41.1"	1759 m	May
4	Andranotsara	S15°00'49.8" E48°13'55.8"	178 m	June
5	Beanamalao	S15°28'45.7" E48°10'44.4"	227 m	June
6	Betsatsika	S15°19'53.3" E48°20'45.2"	294 m	June
7	Ambarijeby	S14°53'20.9" E47°43'17.8"	147 m	July
8	Bekofafa	S14°52'40.2" E47°44'37.9"	143 m	August
9	Ankaramikely	S14°46'50.5" E47°47'52.3"	199 m	August
10	Ambararata	S15°04'05.3" E48°34'11.2"	780 m	December
11	Mahadera	S15°02'24.4" E48°33'33.8"	366 m	December

encounter frequencies of mouse lemurs, their population densities and fragment size was tested by using a simple regression analysis (Type VI, all effects). Finally, the influence of the anthropogenic disturbances on the number of nocturnal lemur species, the encounter frequencies and population densities of mouse lemurs was also tested with an ANOVA (Type VI, sigma restricted). All statistical analyses were conducted with STATISTICA 6.0.

RESULTS

A total of six nocturnal lemur species were found during the survey including *Microcebus danfossi*, *Microcebus mittermeieri*, *Cheirogaleus medius*, *Lepilemur grewcockorum* and *Avahi* sp. Traces of aye-aye tooth gnawings on numerous dead tree trunks, traces of nests, and independent interviews with local villagers also suggested the occurrence of *Daubentonia madagascariensis* in some sites (Table 2). The number of nocturnal lemur species in a given site ranged between two and four. Whereas *Microcebus* spp. and *C. medius* were present in all sites, the three larger species were absent from six (*D. madagascariensis*), eight (*L. grewcockorum*) and ten (*Avahi* sp.) sites. The highest number of species was found in Anjajavy, Ambarijeby and Bekofafa. Fragments of different levels of disturbance differed as a statistical trend with regard to the number of nocturnal lemur species that were found ($F(2,8) = 3.5421$, $p = 0.079$). Fragments of disturbance level 3 tended to host fewer lemur species than fragments with lower levels of disturbance (Figure 2-a1).

Microcebus danfossi was found in ten sites up to a maximum altitude of 780 m a.s.l. (site 10, confirmed by molecular data, Radespiel unpubl. data). Site 3 (Antambato) contained *M. mittermeieri*, which was also confirmed by molecular data (Radespiel unpubl. data). The abundance of *Microcebus* spp. along the census trails ranged from 4.5 to 8.5 individuals per kilometre with the highest values in Anjajavy, Antonibe and Beanamalao. The population density estimates of *M. danfossi* varied from 2.2 to 5.0 individuals per hectare with the highest values being estimated for Antonibe, Beanamalao, Ambarijeby and Mahadera (Table 3). *Lepilemur grewcockorum* was found in three sites only (Anjajavy, Ambarijeby and Bekofafa). If present, their abundance along the census trails ranged from 0.8 to 1.0 individual per kilometre. Sportive lemurs were detected at a mean perpendicular distance of 2.9 m (n = 4, site 8) and 11.6 m (n = 5, site 1) from the trail. Fragment sizes varied from 50 to 400 ha. The sites of Anjajavy and Beanamalao were the largest forests followed by Ankaramikely. With regard to the degree of anthropogenic disturbances, the sites Anjajavy, Ankaramikely, Antambato, and Bekofafa were in the best condition of all visited sites (Table 3). Not surprisingly, the ANOVA revealed that fragments of the three different degrees of disturbance differed in size ($F(2,8) = 4.9714$, $p = 0.03952$, Figure 2b). Fragments with the highest level of disturbance were significantly smaller ($mean_{D3}$ ± SD: 70 ± 40 ha) than fragments of a lower level of disturbance ($mean_{D1}$ ± SD: 265 ± 52 ha, $mean_{D2}$ ± SD: 270 ± 73 ha). A regression analysis, however, revealed no significant relationship between fragment size and encounter frequency ($R^2 = 0.070$, $F(1,9) = 0.67958$, n.s.) or population density ($R^2 = 0.037$, $F(1,9) = 0.34640$, n.s.) of mouse lemurs. Fragments of different levels of disturbance also did not differ significantly in encounter frequencies (ANOVA, $F(2,8) = 0.28833$, n.s.), but differed as a statistical trend with regard to population densities (ANOVA, $F(2,8) = 3.3612$, $p = 0.087$). Interestingly, population densities of mouse lemurs tended to be higher in fragments with a higher level of disturbance (Figure 2-a2). In contrast *L. grewcockorum* was never found in fragments of the highest level of disturbance (level 3, Table 3).

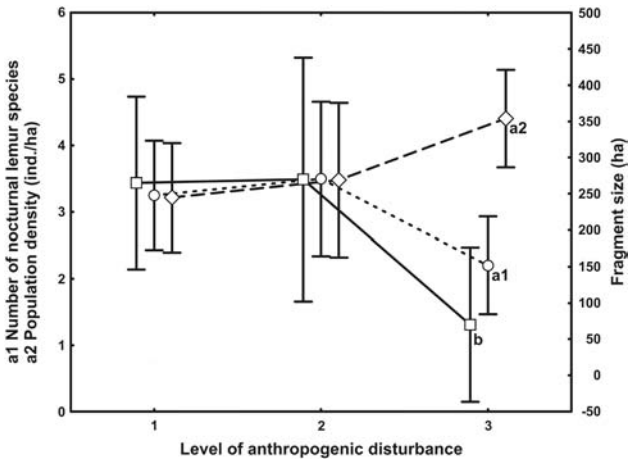

FIGURE 2. a) Effect of the level of disturbance on (a1) the number of nocturnal lemur species that were present in the forest fragments (circles with dotted line), (a2) the population densities of mouse lemurs (diamonds with dashed line), and (b) differences in fragment size between sites of different levels of disturbance (squares with continuous line). Means and 95% confidence intervals (error bars) are shown.

TABLE 2. Presence/absence of nocturnal lemur species in the eleven study sites. +: Species observed during census observations, 1: by interviews with local guides, 2: presence of trace of nest.

Site no.	Site	*Microcebus danfossi*	*M. mittermeieri*	*Cheirogaleus medius*	*Lepilemur grewcockorum*	*Avahi sp.*	*Daubentonia madagascariensis*
1	Anjajavy	+		1	+		1
2	Antonibe	+		1			
3	Antambato		+	1		+	
4	Andranotsara	+		1			1.2
5	Beanamalao	+		1			1
6	Betsatsika	+		1			
7	Ambarijeby	+		+	+		2
8	Bekofafa	+		1	+		1
9	Ankaramikely	+		1			
10	Ambararata	+		1			
11	Mahadera	+		1			

TABLE 3. Characterization of the study sites, encounter frequency and population density of *Microcebus danfossi*, and encounter frequency of *Lepilemur grewcockorum* at each site.

Sites	Estimated area of the forest (ha)	Overall state of the forest (1: good, 2: average, 3: bad)	Encounter frequency of *Microcebus* spp. ± SD/km	Encounter frequency of *L. grewcockorum* ±SD/km	Population density (ind/ha) of *Microcebus* spp.
Anjavavy	400	1	8.5 ± 4.2	0.8 ± 0.5	3.7
Antonibe	50	3	8.0 ± 0.0		5.0
Antambato	150	1	4.8 ± 3.9		2.2
Andranotsara	100	3	6.8 ± 0.4		4.1
Beanamalao	400	2	8.0 ± 2.8		4.3
Betsatsika	70	3	5.8 ± 1.8		4.6
Ambarijeby	140	2	4.7 ± 1.9	+	2.7
Bekofafa	160	1	6.5 ± 5.0	1 ± 0.8	3.4
Ankaramikely	350	1	6.0 ± 0.7		3.6
Ambararata	70	3	7.0 ± 0.7		3.5
Mahadera	60	3	7.8 ± 0.2		4.8

DISCUSSION

The eleven study sites were very different in forest size and in their diversity of nocturnal lemurs. In general, the results were similar to those of a previous study by Olivieri et al. (2005), except that we could never confirm the presence of *Mirza* sp. or *Phaner* sp. in our study. In contrast, we found *Microcebus* spp. and *Cheirogaleus medius* in all sites. These genera seem to be able to live in degraded and/or small forests independent of the variation in forest size and the level of disturbance. Interestingly, population densities of mouse lemurs were even higher in sites with high levels of disturbance. Since this effect was not seen in the encounter frequencies, it is probably not based on systematic differences in visibility between sites. One potential explanation could be a crowding effect in smaller fragments in which dispersal options are highly limited. Another potential explanation could be an edge effect in mouse lemurs. Mouse lemurs have previously been found to frequently use forest edges as feeding sites (Ganzhorn 1995, Lehman et al. 2006) and to develop rather high population densities in secondary forests (Ganzhorn and Schmid 1998). These effects could potentially lead to increased population densities in rather open and disturbed forests that contain many 'artificial edges'.

Encounter rates of *Microcebus danfossi* were generally comparable to those of other studies on western mouse lemurs (Supplementary Material), but low compared to populations that inhabit larger protected zones like the Ankarafantsika National Park (135,000 ha). For example, Rakotondravony and Radespiel (2007) reported site-specific abundances of *Microcebus* spp. in the dry forest of Ankarafantsika National Park, ranging from two to 26 individuals per kilometre. The lack of such high numbers in our study may be due to negative effects of habitat degradation or habitat fragmentation on mouse lemurs in the Sofia region that may have been caused by direct forest exploitation (for construction, charcoal etc.) or by the repeated occurrence of bush fires which may also enter forests and can alter the habitat structure and the floristic composition of forests substantially (Bloesch 1999). Negative effects of fragmentation have previously been shown for other lemur species (Ganzhorn 1994, Ganzhorn et al. 2000, Lehman et al. 2006, Irwin and Raharison 2009, Irwin et al. 2010).

Alternatively, *Microcebus danfossi* may naturally occur in relatively low population densities. This hypothesis is supported by the observation that *M. danfossi* has relatively low abundance values when compared to other species that were studied in disturbed forest fragments in the same biogeographic region (northwestern Madagascar) with the same methodological approaches (Supplementary Material, Olivieri et al. 2005).

Potentially, two more factors could explain low encounter rates in the surveyed forest fragments: (1) Seasonal changes in visibility or activity pattern (Schmid and Kappeler 1998, Atsalis 2000, Randrianambinina et al. 2003, Rasoazanabary 2006, Lehman 2006), or (2) ecological differences between the sites causing differences in the carrying capacity of the habitats (Rakotondravony and Radespiel 2009). Seasonal effects are not very likely, since neither the encounter frequencies nor the density estimates increased or decreased significantly over the course of the year (results not shown). Potential ecological differences between the visited forest fragments, however, cannot be excluded and this aspect certainly needs further attention.

The highest encounter rates of mouse lemurs and sportive lemurs were found in the coastal site Anjajavy, one of the largest and most intact forests. Most likely, the presence of the Anjajavy Hotel in the immediate vicinity of this forest, which provides local villagers with employment, contributed to this relative intactness. The hotel may have a stabilizing effect on the financial situation of the villagers, reducing the need to exploit the natural resources of the forest. *Lepilemur grewcockorum* was only found in three of 11 sites. Encounter rates of *L. grewcockorum* were generally low compared to data on sportive lemurs in many other parts of Madagascar (Supplementary Material), but show similarities to the results of the study by Olivieri et al. (2005) in the same region. It has previously been shown that sportive lemurs have more difficulties coping with habitat changes such as an increasing degree of habitat fragmentation and habitat degradation than mouse lemurs (Ganzhorn 1994b, Ganzhorn et al. 2000, Olivieri et al. 2005). Sportive lemurs were previously reported to sleep in tree holes during the dry season and in tangles of vines and leaves during the rainy season (Rasoloharijaona et al. 2003,

2008). Forest quality determines the availability of tree holes because mature forests, but not degraded forest, are more likely to harbour old and hollow trees. Thus, the long-term survival of sportive lemurs with their very fragmented and limited distribution (Craul et al. 2007) may critically depend on the availability of intact forests providing not only sufficient food and suitable substrates for locomotion (Ganzhorn 1988), but also a sufficient number of suitable shelters for daytime resting. As shown for other sportive lemurs, *L. grewcockorum* also suffers from a high hunting pressure (Olivieri et al. 2005). These animals are easy and defenceless prey for hunters that find their sleeping sites during the day and cut the tree down or climb it to fetch them.

The limited and fragmented distribution of *Microcebus danfossi* and *Lepilemur grewcockorum* indicate that they are much more threatened than previously thought. The IUCN Red List of Threatened Species is recognized as the most comprehensive, objective global approach for evaluating the conservation status of plant and animal species. It plays an increasingly important role in guiding conservation decisions of governments and NGOs. It has introduced a standard in defining the risk of extinction which is universally applicable to all species (IUCN 2001). Based on the latest IUCN Red List, *M. danfossi* and *L. grewcockorum* were so far categorized as 'data deficient'. Based on the results of this and a previous study (Olivieri et al. 2005), and in view of the IUCN criteria (IUCN 2001), we propose the following revision of this status: 1) Although the area between the rivers Sofia and Maevarano covers about 11,000 km^2, the actual extent of occurrence of *M. danfossi*, estimated as a minimum convex polygon around all known sites of occurrence, covers only about 7,600 km^2 (Table 4, Radespiel unpubl. data). Based on this limited size, the severe degree of habitat fragmentation and the continuing decline of habitats, we propose *M. danfossi* to be categorized as Vulnerable (B1ab(iii), Table 4). 2) The actual extent of occurrence of *L. grewcockorum*, estimated as a minimum convex polygon around all known sites of occurrence, covers only about 1,200 km^2 (Radespiel unpubl. data). Based on this small size, the severe degree of habitat fragmentation in the area, the continuing decline and disturbance of habitats, their disappearance from many sites and the severe hunting pressure on the remaining free-living populations, we propose *L. grewcockorum* to be categorized as Endangered (B1ab(iii), Table 4).

Based on fragment size, overall state of the forest and presence of both regional endemics, *Microcebus danfossi* and *Lepilemur grewcockorum*, Anjajavy qualifies best for intensified conservation efforts. However, given that the genetic and ecologic diversity of species cannot be preserved by protecting one population only, all remaining known populations of *L. grewcockorum* are recommended to receive conservation attention. These are Anjiamangirana I and Ambongabe from a previous study (Olivieri et al. 2005) and Ambarijeby and Bekofafa from this study.

CONCLUSIONS

The fragments in the Antsohihy region differed largely in the number of inventoried lemur species, fragment size, and anthropogenic disturbance. Whereas *Microcebus* sp. could be found in all sites, *Lepilemur grewcockorum* was already absent from most fragments, and can therefore be assumed to be much more sensitive to habitat changes than the much smaller mouse lemurs. Based on these newly available data on the presence and abundance of the two recently described regional endemics, the conservation status of both lemur species could be defined for the first time and reveals the urgent need for effective conservation activities in this area. Since none of the visited fragments is so far formally protected, we recommend five fragments with a high conservation potential to be included in the future conservation management of the Antsohihy region. Any protected forest that ensures the long-term survival of *L. grewcockorum,* will also serve to protect many more forest-dwelling species, and among these will certainly also be *M. danfossi.*

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TABLE 4. Evaluation of the IUCN criteria for the classification of both lemur species. ?: data not yet available.

IUCN criterion - Criterion B – "geographic range"	*M. danfossi*	*L. grewcockorum*
Category Endangered: 1. + at least two of a-c		
1. Extent of occurrence < 5000 km^2	~ 7,600 km^2 - no	~ 1,200 km^2 - yes
a. severely fragmented	Yes	Yes
b. continuing decline, based on		
(i) extent of occurrence	?	?
(ii) area of occupancy	?	?
(iii) area, extent and/or quality of habitat	Yes	Yes
(iv) number of locations or subpopulations	?	?
(v) number of mature individuals	?	?
c. Extreme fluctuations	?	?
Conclusion	not B1	à Endangered, B1ab(iii)
Category Vulnerable: 1. + at least two of a-c		
1. Extent of occurrence <20,000 km^2	~ 7,600 km^2 - yes	
a. Severely fragmented	Yes	
b. Continuing decline, based on		
(i) extent of occurrence	?	
(ii) area of occupancy	?	
(iii) area, extent and/or quality of habitat	Yes	
(iv) number of locations or subpopulations	?	
(v) number of mature individuals	?	
c. Extreme fluctuations	?	
Conclusion	à Vulnerable, B1ab(iii)	

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SUPPLEMENTARY MATERIAL.

AVAILABLE ONLINE ONLY.

S1: Summary of previously published encounter frequencies and population densities of *Microcebus* spp. and *Lepilemur* spp. in western and eastern Madagascar, respectively. Forest sizes were added whenever they were available from the literature. (?): Taxon was not confirmed with molecular methods until now, ?: Forest size not mentioned.

ARTICLE

Monitoring and conservation of the Critically Endangered Alaotran gentle lemur *Hapalemur alaotrensis*

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ABSTRACT

The Alaotran gentle lemur *Hapalemur alaotrensis* is a Critically Endangered lemur, which exclusively inhabits the marshes around Lac Alaotra in northeast Madagascar. In the past decades the population of *H. alaotrensis* has experienced a dramatic decline due to poaching, habitat destruction and degradation. Surveys have been carried out periodically to follow the status of the population. Here we present the results of a survey carried out between May and June 2008 in the southwestern part of the marshes around Alaotra and discuss the key findings derived from the analysis of the data collected. Our study indicates that the probability of detecting the species in an area where it is present is very low and depends on factors that vary in space and time. These results stress the need to account for imperfect detection when monitoring this species, an issue especially relevant when reporting population trends. Our analyses also show that habitat fragmentation is a key determinant of habitat suitability for *H. alaotrensis*, with fragmented areas of marsh showing low suitability. Finally, our observations and analysis suggest that the protection provided by the local community to *H. alaotrensis* in Andreba is contributing to the conservation of this Critically Endangered species. This highlights the need to continue working on engaging the local communities in the conservation of the marshes at Lac Alaotra as a critical element to secure the future of *H. alaotrensis.*

RÉSUMÉ

L'Hapalémur du lac Alaotra *Hapalemur alaotrensis* est un lémurien en danger critique d'extinction qui habite exclusivement dans les marais autour du lac Alaotra au nord-est de Madagascar. La population de *H. alaotrensis* a connu un déclin dramatique au cours des dernières décennies à cause du braconnage et de la destruction et la dégradation de son habitat.

Des suivis écologiques ont été réalisés périodiquement pour appréhender la situation de la population. Nous présentons ici les résultats d'un suivi écologique effectué entre mai et juin 2008 dans la partie sud-ouest du marais de l'Alaotra et nous examinons les principales conclusions dérivées de l'analyse des données obtenues. À partir de données de détection / non-détection, nous avons procédé avec une technique de modélisation de l'occupation de l'habitat qui tient compte explicitement de la probabilité de détecter l'espèce, en permettant d'introduire des co-variables pour expliquer l'occupation et la détectabilité. Notre étude montre que dans les zones où l'espèce est présente, la probabilité de la détecter est très basse et dépend de facteurs qui varient dans l'espace et le temps. Ces résultats mettent en exergue le besoin de considérer que la détection de cette espèce n'est pas parfaite, aspect particulièrement important dans l'étude des tendances de populations. Nous avons également utilisé les coordonnées des localités où les lémuriens ont été observés pendant le suivi ainsi que des variables prédictives obtenues à partir d'images du satellite Landsat7 pour la zone de l'Alaotra afin de modéliser la qualité de l'habitat pour *H. alaotrensis* avec le logiciel Maxent et produire une carte du marais de l'Alaotra qui peut servir d'outil à la gestion du marais dans le cadre de la protection de cette espèce. Notre analyse montre également que la fragmentation de la végétation du marais est un facteur déterminant de la qualité de l'habitat, les zones les plus fragmentées étant les moins favorables. Finalement, nos observations et nos analyses suggèrent que la protection fournie par la communauté locale d'Andreba-Gare contribue à la protection de cette espèce en danger critique d'extinction. Cet aspect souligne l'importance de poursuivre le travail de sensibilisation des communautés locales dans la protection du marais du lac Alaotra comme élément critique pour assurer la survie de *H. alaotrensis*.

KEYWORDS: bandro, habitat suitability, habitat fragmentation, imperfect detection, Maxent.
MOTS CLEFS : bandro, modélisation de l'habitat, fragmentation, détection imparfaite, Maxent.

INTRODUCTION

The Alaotran gentle lemur *Hapalemur alaotrensis* (Rumpler 1975), initially regarded as a subspecies of the lesser gentle lemur *Hapalemur griseus* but currently considered a

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separate species (Groves 2005), only occurs in the marshes around Lac Alaotra, in the Alaotra-Mangoro Region, northeast Madagascar. With around 20,000 ha of open water area, Lac Alaotra is Madagascar's largest lake and constitutes one of the main inland fisheries in the country. The lake is surrounded by a vast wetland consisting of marshes and rice fields and is considered an important biodiversity area (Pidgeon 1996). Due to its biological value, the whole Alaotra watershed was designated a wetland of international importance under the Ramsar Convention in 2003 (Ramanampamonjy et al. 2003). *Cyperus madagascariensis* and *Phragmites communis* dominate the vegetation in the marsh. In the past decades large areas of marsh have disappeared as a result of conversion into rice paddies. The Alaotran basin produces a large proportion of the national rice harvest (Pidgeon 1996) and is popularly known as 'the granary of Madagascar'. While estimates of original extent of natural marsh range from 60,000 to 80,000 ha (Mutschler and Feistner 1995), at present the remaining marsh surface is less than half of that (Ramanampamonjy et al. 2003, Bakoariniaina et al. 2006) and suffers from degradation through uncontrolled burning (Copsey et al. 2009), siltation due to erosion in the surrounding hills and the spread of invasive plants. The severe loss and degradation of the marsh, together with pressures from hunting, fishing and exotic species, is threatening the survival of various local species. In 2007 a *Nouvelle Aire Protégée* NAP (IUCN category VI protected area) was declared to officially protect the Alaotran marshes. The NAP set out a number of management zones for the marsh and open water, including no-fishing zones, areas for strict biodiversity conservation, and areas of regulated fishing and reed extraction, although no formal management authority exists yet to ensure compliance.

Hapalemur alaotrensis is the only primate known to exclusively inhabit marsh vegetation. It occurs in two subpopulations: A very small one in the northern part of Lac Alaotra around the Belempona Peninsula and a larger one in the southwestern marshlands. *H. alaotrensis* is highly territorial, with groups actively defending their home ranges against incursions by other groups (Nievergelt et al. 1998). Social groups generally range from two to nine individuals (mean = 3.3, Mutschler and Feistner 1995; mean = 4.3, Nievergelt et al. 2002) and occupy home ranges of 0.6-8 ha (Mutschler and Tan 2003) with a mean home range size of around two hectares (Mutschler et al. 1994). This species can be active throughout the day and night, with peaks of activity at the beginning and end of the daylight cycle (Mutschler et al. 1998). *H. alaotrensis* is exclusively folivorous and feeds on only a few species, mainly *Cyperus madagascariensis*, *Phragmites communis* and *Echinochloa crusgalli* (Mutschler et al. 1998). It may require tall strong vegetation for moving across the marsh and it has been observed in previous studies mostly in mature *C. madagascariensis* and *P. communis* stands with a diversity of undergrowth species, typical of areas where marsh fires have not occurred in several years (Ralainasolo 2004a). Man-made channels often mark territory boundaries; although *H. alaotrensis* can swim, they rarely do and seem to avoid open water (Mutschler et al. 1994). We can therefore hypothesize that the habitat fragmentation that can result from uncontrolled fires in the marsh would have a strong negative impact on *H. alaotrensis,* considering its locomotion style based on leaping and walking on bent stems along contiguous vegetation, but the influence of habitat fragmentation or plant species diversity on habitat suitability has not yet been investigated systematically.

Hapalemur alaotrensis is classified as Critically Endangered by the IUCN (IUCN 2009). Its survival is threatened by the destruction and degradation of its marsh habitat as well as poaching. These factors appear to have caused a dramatic decline in the population in recent decades (Ralainasolo et al. 2006). Despite laws protecting lemurs in Madagascar, illegal hunting has been identified as a key threat for this species (Mutschler et al. 2001). Some poaching still occurs, although it is believed that awareness and educational campaigns carried out around the lake have reduced its intensity (Ralainasolo 2004b; B. J. Rasolonjatovo, pers. comm.).

Since 1990, Durrell Wildlife Conservation Trust has been engaged in the conservation of *Hapalemur alaotrensis* and has conducted surveys to track the status of the population. Prior to this, very little fieldwork had been conducted on this species (Petter and Peyrieras 1970, Pollock 1986). In 1994 a six-month field study assessed its distribution, population and conservation status (Mutschler and Feistner 1995). Abundance was estimated using a method based on relating the number of 'groups encountered per hour of search' in different areas of the marsh to the group encounter rate from an area where density had been measured based on marked and radio-collared individuals, that is, calibrating a population index (Sutherland 2006: 165) but using a single calibration point and assuming a linear relationship and zero intercept. In 1999, a two-month survey was carried out following the same methods to estimate group encounter rates and compare them with the 1994 figures (Mutschler et al. 2001). In 2001 and 2002, surveys based on the same field protocols collected data to estimate abundance based on encounter rates of individuals (Ralainasolo 2004b).

Monitoring *Hapalemur alaotrensis* is not easy. The species is difficult to detect since visibility is restricted to the first few metres of vegetation and access to the marsh is limited to canals cut by fishermen. Given the characteristics of the Alaotra system, it is reasonable to expect some degree of variation in the conditions that determine the likelihood of detecting the species in areas it occupies (e.g., changes in water level may cause differences in detectability). The previously used monitoring method based on encounter rates did not account for potential spatio-temporal variation in detection probability, which may confound true changes in population: It is not possible to distinguish an increase in population from an increase in detection probability. Another important limitation of the previous monitoring methodology is that the calibration of the population index (i.e., encounter rate) using only one calibration point does not allow for the quantification of the uncertainty associated with the estimate. Occupancy, defined as the probability of a site being occupied by the species, is often considered a useful variable for the monitoring of rare and elusive species as it can provide sufficient information about the status of the population and detection / non-detection data are relatively easy to collect (MacKenzie et al. 2006). A framework for modelling occupancy while accounting for imperfect detection is thus an attractive alternative to current methods for monitoring *H. alaotrensis*, as it helps discriminate changes in occupancy from changes in detectability, and provides a quantification of the uncertainty associated with the estimates.

In this paper we present the key findings of the analysis of data collected during a survey carried out between May and June 2008 in the southwestern part of the Lac Alaotra marshes. We analyzed these data to (1) calculate encounter rates of *Hapalemur alaotrensis*; (2) estimate the probability of site occupancy of this lemur and evaluate how it is affected by relevant covariates; (3) explore how different factors affect the probability of detecting *H. alaotrensis* in areas occupied by the species; (4) investigate daily activity patterns to identify optimal times for monitoring and (5) build a model of habitat suitability based on habitat characteristics derived from satellite imagery. The part of the study addressing (2) and (3) was originally published in Guillera-Arroita et al. (2010), and (5) in Lahoz-Monfort et al. (2010). Here we discuss all the results in the context of previous studies and examine their implication for the monitoring and conservation of this Critically Endangered species.

METHODS

DATA SAMPLING. We conducted surveys through the marsh during the dry season between 21 April and 4 June 2008, concentrating on the area between the villages of Anororo, Andreba Gare, Andilana Atsimo and Ambodivoara, where the southern and largest population of *Hapalemur alaotrensis* occurs. We accessed the marsh from these villages and carried out transects within their 'village management zones' (areas of marsh regulated by the community for fishing and reed harvesting). The survey was conducted by canoe at a regular speed (ca. 1-3 km / h) along existing channels used by fishermen and bordering lake vegetation (Figure 1). We made repeat visits to each transect (from three to 12, six on average) to obtain the information needed to account for the 'imperfect detection' of the species. Two teams carried out surveys twice a day, in the early morning (0530-0900h) and in the afternoon (1500-1800h), when the lemurs are more active. Each team consisted of one researcher, one local expert (Alaotra fishermen experienced in assisting in the scientific work of Durrell Wildlife Conservation Trust) and one local villager as additional paddler. Teams rotated in surveying transects to avoid heterogeneity in the data due to observer effects. Transects were surveyed in a different order when possible to avoid visiting the same sites at the same time of day.

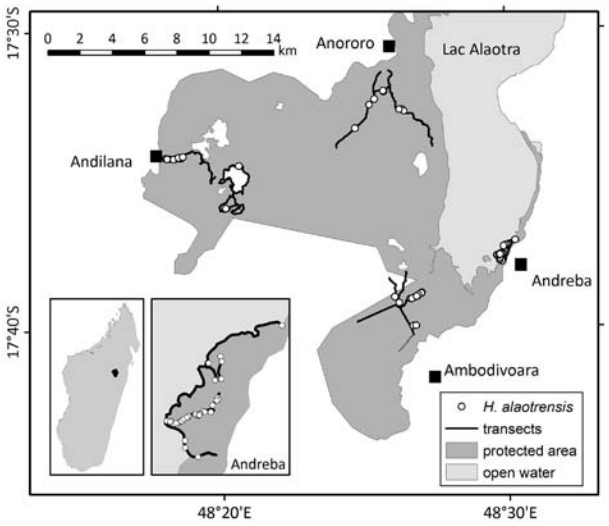

FIGURE 1. Survey transects and position of *Hapalemur alaotrensis* encounters. The Nouvelle Aire Protégée covers most of the remaining Alaotra marsh. The four villages used as bases for the study are also shown. Detail on the surveyed area in Andreba is shown in an inset. A section of the Sahabe River (dotted line) was also visited once but was excluded from our surveys as most of the marsh area had been recently converted into rice paddies.

We collected data on direct observations of *Hapalemur alaotrensis*, including the time of day, the number of individuals spotted in each group and their activity. The location of each sighting was recorded with a GPS. We recorded qualitative information on habitat characteristics at 30 m intervals along transects, including the main structural species, species composition and an overall impression of habitat density and patchiness. The average number of canoes encountered per hour of survey was recorded for each transect as an indication of traffic at the time of survey.

DATA ANALYSIS. The data were used to perform an exploratory analysis of activity patterns. We calculated the percentage of group encounters in which the lemurs were engaged in different activities categorized as feeding, moving amongst the vegetation, scent marking or defending their territory, grooming and resting. We examined how group encounter rates change with the time of the day by comparing the number of sightings with the total amount of time spent in the marsh, broken into 20-minute time intervals. For this we also considered the periods of time spent in the marsh accessing and returning along transects, even if outside the established surveying times. For each of the four village management zones surveyed (Andreba, Anororo, Ambodivoara and Andilana) we calculated group encounter rates by dividing the total number of group encounters by the total time spent actually surveying. These figures were then compared to those from previous studies.

The detection data were analyzed using an occupancy modelling framework (MacKenzie et al. 2006) that allows the estimation of the probability of site occupancy while accounting for imperfect detection. The method consists on a sampling protocol that involves repeated surveys at a number of sampling sites. This repetition in surveys provides information that allows the model to account for species imperfect detection by explicitly considering that the apparent absence of the species at a site during a survey may reflect two possible situations: 1) the species was truly absent at the site or 2) the species was present at the site but was missed in the survey (i.e., false absence). We used maximum-likelihood as a method for inference and defined as sampling sites sections of transect of 150 m, roughly the size of an average home range. We incorporated into the model four site characteristics thought to be relevant (canoe traffic, habitat category, lake edge vs. channel, nearest village) to explore their effect on the probability of occupancy and detection. Recorded canoe traffic was used to identify infrequently used transects (<1 canoe per hour of fieldwork) from those with moderate or high traffic (>1 canoe per hour of fieldwork). Habitat category was assigned to each sampling site based on the habitat information collected in the field, following the classification used by Mutschler et al. (2001), with an additional class for 'patches of floating invasive plants, large patches of grass or extremely low density stands of *Cyperus madagascariensis*'. Habitat category was used as a proxy of habitat characteristics in the area, but given that data only captured the characteristics of the first metres of vegetation it may not always have provided an accurate description of the habitat beyond. For more details on covariates, model fitting and model selection see Guillera-Arroita et al. (2010).

We used freely available Landsat7 satellite images from March 2007, with a pixel resolution of 30m, to create a model of habitat suitability for *Hapalemur alaotrensis* with the free software Maxent v3.2.1 (Phillips et al. 2006), which applies the maximum entropy modelling framework (Jaynes 1957) to habitat suitability modelling. It attempts to find the least constrained (maximum entropy) distribution that agrees with all the observed data (the value of the covariates at locations where the species was detected). The method only requires presence records although randomly selected background locations are used to characterise the features. It has been shown to perform well compared to other habitat modelling techniques even with only a few samples (Elith et al. 2006). Model validation was based on AUC, the Area Under the ROC (Receiver Operating Characteristic) Curve, which provides a threshold-independent evaluation statistic of model performance. An AUC of 0.5 indicates a prediction no better than random while the closer the values are to 1 the better the model is able to predict. In order to obtain ROC curves and AUC figures, *H. alaotrensis* presence points were randomly divided into calibration (training) and evaluation (test) sets, with 25 % of the samples for evaluation. The modelling was performed 1,000 times with different random partitions of evaluation and calibration sets, and evaluation AUC figures were averaged to avoid them being influenced by particular lemur sightings. All predictor variables were derived from the Landsat7 images and included vegetation indices (related to plant productivity) and image textures (related to habitat fragmentation). Image textures were calculated at different scales, based on a moving window with sizes ranging from three to 11 pixels, which allowed us to study the effect of habitat fragmentation on habitat suitability at different scales potentially relevant for *H. alaotrensis*, whose average territory size (i.e., two hectares) would correspond approximately to 5x5 pixels and maximum (i.e., eight hectares) to around 9x9 pixels. We note that our modelling approach does not assume preconceived habitat categories based on previous knowledge, as this would introduce circularity in our analysis. For further details on the remotely sensed covariates, variable selection procedure and modelling methods, see Lahoz-Monfort et al. (2010).

RESULTS

In 120 hours of survey in the marsh, 71 encounters of *Hapalemur alaotrensis* groups were recorded (Figure 1). This number includes repeated encounters in different surveys of some groups. *H. alaotrensis* encounters were relatively frequent in some areas while no groups were found in others, which suggests that the presence of the species or the probability of detection, or both, depend on characteristics of the sites surveyed. The number of individuals recorded in each group encounter ranged from one to eight (average = 2.9; Figure 2). These group sizes are somewhat lower than those reported in the literature, which could indicate that some individuals within the groups remained undetected during our surveys.

Encounter rates were similar during the morning and afternoon surveys (Figure 3). Very few groups were encountered after 0830h despite considerable survey effort. Observations before 1600h were also rare. Groups observed were engaged in different activities, which we recorded for 55 group encounters: Feeding (45.5 %), moving through the vegetation (21.8 %), marking or defending their territories against other neighbouring groups (14.5 %). A few groups were observed resting amongst the vegetation (12.7 %) and grooming (5.4 %). 57.8 % of the groups were seen on *Cyperus madagascariensis*, 29.6 % on *Phragmites communis* and the remaining 12.7 % on mixed vegetation (including grass patches, mostly in Andreba).

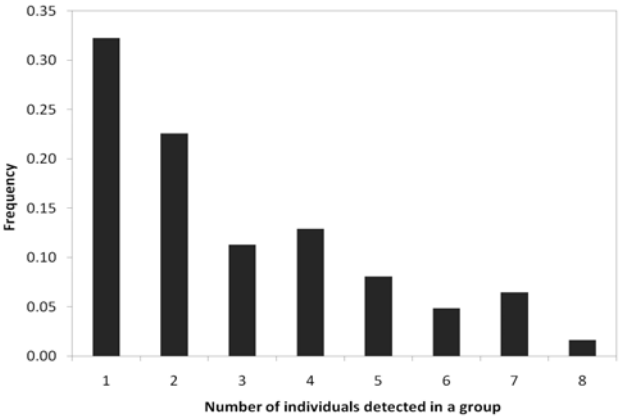

FIGURE 2. Frequency of the number of *Hapalemur alaotrensis* individuals recorded in each group encounter. These figures represent a lower limit for group size as some individuals might have been missed by the observers.

Group encounter rates (Table 1) varied substantially between village management zones. Encounters were frequent in the area of marsh surveyed in Andreba while the lowest encounter rates were found around Anororo. Compared to the figures from previous studies, encounter rates were relatively high. The figure from Andreba (1.59 group encounters per hour) was twice the largest rate previously recorded (0.72 in 1994) and substantially higher compared to those from other villages. Note that in Andreba we only surveyed the northern part of the marsh while other studies (e.g., Mutschler et al. 2001) may have surveyed the southern part of the marsh as well, where encounter rates tend to be lower. In Ambodivoara the encounter rate was also the largest recorded (0.48), but similar to the second largest (0.40 in 1999). The encounter rate in Andilana (0.40) was slightly lower than the highest recorded (0.47 in 1994), but higher than later figures. In Anororo the figure was roughly half the maximum encounter rate recorded (0.28 vs. 0.51) but several times higher than in more recent surveys.

The results of jointly modelling the probability occupancy and detection (Guillera-Arroita et al. 2010) indicate that these two quantities are not constant but depend on site characteristics (Table 2). Our models estimated that the average probability of site occupancy for the area surveyed was 0.208 (SE = 0.043)

TABLE 1. Encounter rates of *H. alaotrensis* groups during the 2008 survey compared to figures from previous surveys. ER: Group encounter rate (groups per hour). Note that the areas surveyed in each locality may vary among different years. 1) Mutschler and Feistner (1995), 2) Mutschler et al. (2001), 3) Ralainasolo (2004b).

	2008			1994 (1)	1999 (2)	2001 (3)	2002 (3)
Locality	Group encounters	Survey time (min)	ER	ER	ER	ER	ER
Andreba	32	1210	1.59	0.72	0.36	0.56	0.67
Ambodivoara	15	1878	0.48	----	0.40	0.07	0.27
Andilana	15	2226	0.4	0.47	0.07	0.02	0.15
Anororo	9	1922	0.28	0.51	0.25	0.08	0.07

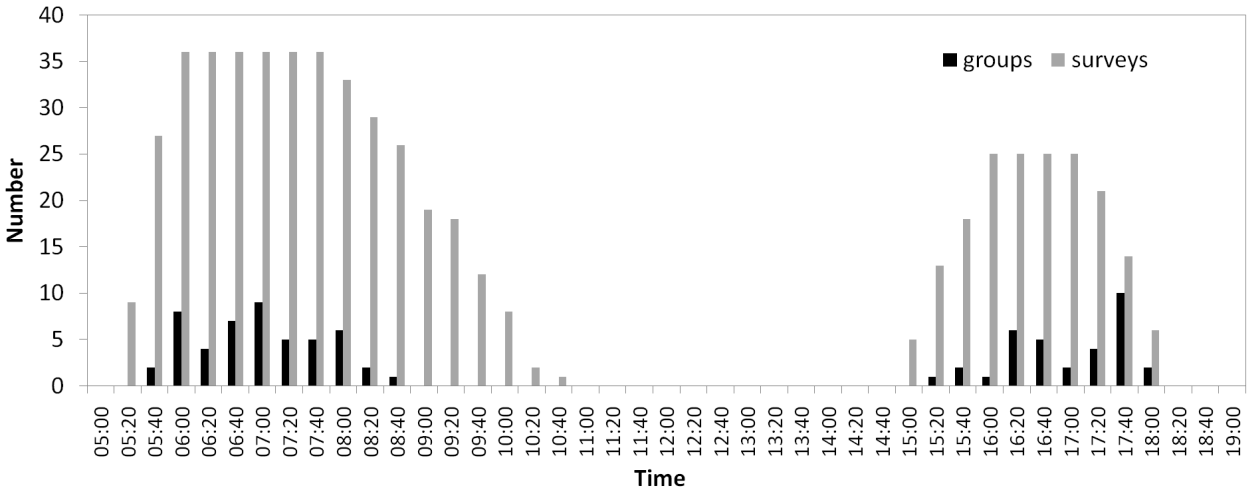

FIGURE 3. Number of visits to the marsh and number of group encounters of *Hapalemur alaotrensis*, in 20-minute time intervals.

and suggest that occupancy depends on the characteristics of the habitat at the site, which village manages the area and whether the site is by a lake or a channel. Our analysis showed that, after controlling for other factors such as habitat conditions, the probability of a site being occupied by *Hapalemur alaotrensis* was higher in two of the village management zones surveyed (Andreba and Andilana) compared to the other two (Ambodivoara and Anororo). The models indicated that detection probability is very low for this species and is related to the amount of canoe traffic occurring at the site. According to our estimates, the probability of detecting *H. alaotrensis* at a site which is used by the species was around 18 % for transects with low traffic (less than one pirogue encountered per hour of fieldwork), and as low as 5 % for transects supporting higher levels of traffic (more than one pirogue encountered per hour).

The results of our habitat modelling (with an evaluation AUC of 0.861) suggest that both vegetation productivity and habitat fragmentation are important determinants of habitat suitability for *Hapalemur alaotrensis*. High values of the NDVI (Normalized Difference Vegetation Index), an index of vegetation greenness, increased suitability. High NDVI values are typical of healthy marsh. On the other hand, fragmentation of the marsh reduced suitability, both due to the reduction in the amount of healthy marsh in an area and the patchiness of the fragmented marsh. The spatial scale at which habitat fragmentation was taken into account in the model appeared important, with highest predictive power achieved for different predictors at different scales, from Landsat7 pixel size (30x30 m) up to the average territory size of *H. alaotrensis*. The map of habitat suitability produced with Maxent can be seen in Figure 4. A detailed description of the results in relation to the predictor variables can be found in Lahoz-Monfort et al. (2010).

TABLE 2. Average site occupancy and detectability estimates for *H. alaotrensis* in each of the four areas surveyed. Estimates were obtained averaging models that had similar support (Guillera-Arroita et al. 2010). Standard errors are shown in brackets.

Locality	Occupancy	Detectability
Andreba	0.701 (0.192)	0.084 (0.032)
Ambodivoara	0.197 (0.082)	0.061 (0.063)
Andilana	0.264 (0.059)	0.060 (0.027)
Anororo	0.095 (0.051)	0.051 (0.016)
Overall	0.208 (0.043)	0.063 (0.015)

DISCUSSION

DETECTABILITY.The results of the Guillera-Arroita et al. (2010) occupancy model showed that the probability of detecting *Hapalemur alaotrensis* in areas used by the species is very low and varies with factors that change in space and time. This highlights the need to account for imperfect detection when monitoring the species, both in the design phase of the study and the subsequent analysis of the data. As expected, our data showed that the probability of detecting the species is highly dependent on the time of the day. Monitoring of this species should therefore be carried out during the active periods to maximize the probability of detection and thus optimize the use of monitoring resources. Our analysis identified the amount of canoe traffic as another important factor affecting the probability of detection. We suspect that the effects of water level on visibility may also be relevant, although we could not explore it due to the timeframe of our study. Mutschler et al. (2001) noted a potential decrease in visibility affecting their 1999 survey, as a result of an unusual drought during the first months of the year.

Changes in detection probability can confound estimates of change in populations, making it impossible to interpret observed trends in sightings of lemurs as real population trends. Therefore it is especially important to account for this issue when comparing results from different areas or years, or different studies. A comparison of our data with that of previous surveys (Mutschler and Feistner 1995, Mutschler et al. 2001, Ralainasolo 2004b) using the usual group encounter rate method would suggest an increase in *Hapalemur alaotrensis* population. However, this could also reflect differences in detection probability, for instance due to better visibility conditions or different levels of canoe traffic in the areas selected for survey. Although looking at the encounter rates can provide some insights about the population, we stress the need to use a method of analysis that accounts explicitly for detection probability, like the occupancy framework utilized in our study or alternatively distance sampling (Buckland et al. 2001). The occupancy framework also allows us to incorporate factors that affect both occupancy

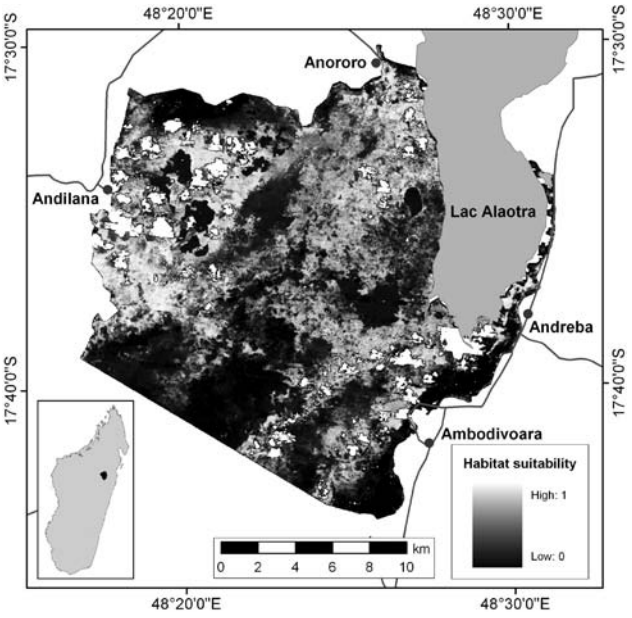

FIGURE 4. Habitat suitability map obtained with Maxent for *Hapalemur alaotrensis* as a continuous index (logistic output). Empty patches correspond to clouds in the Landsat image. This map is reproduced from Lahoz-Monfort et al. (2010).

and detection probability into our models and enables us to generate measures of the reliability of our estimates (i.e., confidence intervals) which is important when making conclusions about trends.

IMPACT OF HABITAT FRAGMENTATION ON HABITAT SUITABILITY. The Lahoz-Monfort et al. (2010) habitat model based on satellite images provided estimates of habitat suitability beyond the bounds of our field surveys along existing channels and lake edges, which is particularly relevant given the extent of the Lac Alaotra marshes that is impenetrable. Both vegetation productivity and low fragmentation contributed to habitat suitability. This may be as expected, but it is noteworthy that our method did not impose preconceived ideas about what constitutes 'suitable' habitat, based upon our ecological understanding or previous experience. This means that the results of the study are not circular (i.e., it would not be surprising to see lemurs in habitat categories that have been defined as suitable a priori based on where you expect to see them). Instead, the method tested whether objective measures of fragmentation and greenness in the satellite image did in fact characterise areas of lemur presence. The results reinforce the understanding of the ecology of the species built up from previous studies, and support the hypothesis that habitat fragmentation has a strong influence on the suitability of the marsh for *Hapalemur alaotrensis*. The relationship estimated by the model for the fragmentation covariates calculated for different sizes suggested that habitat fragmentation affects *H. alaotrensis* at different scales. It suggests that the movement of the lemurs at a small scale is hindered, and the amount of healthy marsh (and thus food and shelter) at a larger scale is reduced within a potential territory. The dynamics of marsh burning are not simple but there is evidence that burnt areas are likely to develop into low quality fragmented habitat (Andrianandrasana 2009). During our survey we did not find a single individual of *H. alaotrensis* in areas burnt within the last year. This highlights the importance for the conservation of *H. alaotrensis* of reducing the amount of large uncontrolled marsh fires and allowing the natural regeneration of the marsh.

THE EFFECTIVENESS OF COMMUNITY INVOLVEMENT IN PROTECTING *HAPALEMUR ALAOTRENSIS*. Our results showed that the probability of an area being occupied by *Hapalemur alaotrensis* varies between village management zones, which could reflect different levels of poaching. Although *H. alaotrensis* is protected and its hunting is illegal, some level of poaching remains. During the time of our study there were reports of poachers being caught and some local villagers acknowledged in informal conversations that hunting still continues in some areas. Our analysis revealed that the probability of occupancy was highest in the marsh surveyed in Andreba, where recorded group sizes also tended to be larger. The habitat in this area was very good for *H. alaotrensis,* as shown by our habitat suitability model. Although not studied quantitatively, our field observations showed marked differences in behaviour between individuals in this area compared to others. Lemurs were more 'docile' and would remain for a longer time close to us. Previous field studies also recorded higher encounter rates in this area compared to other villages. Andreba has been the focus of ecological studies on *H. alaotrensis* for years, which, together with the environmental awareness projects carried out around the lake (Andrianandrasana et al. 2005, Maminirina et al. 2006), have raised the awareness of the local community of the importance of the conservation of *H. alaotrensis*. A community park (*Parc villageois d'Andreba*) was created to regulate the access to this part of the marsh and recently a sustainable nature tourism project was set up by the Malagasy NGO Madagascar Wildlife Conservation to bring more incentives for the community to protect the species. Our observations and analysis indicate that the involvement of the local community in the protection of *H. alaotrensis* in Andreba is contributing to the conservation of this Critically Endangered species. This highlights the need to continue working in the engagement of local communities around the lake as part of the long-term conservation strategy for the marshes of Lac Alaotra.

CONCLUSIONS

Our study showed that *Hapalemur alaotrensis* is affected by the fragmentation of its habitat and the quality of the vegetation. This emphasizes the need to avoid large uncontrolled destruction of the marsh (e.g., due to fires) and to allow its natural regeneration. Our data and observations suggested that the engagement of the local community is an effective conservation measure and that it is therefore important to continue working in this direction. By tracking *H. alaotrensis* population changes, monitoring can inform decisions regarding its conservation. For monitoring to be meaningful, it is critical to account for the imperfect detection of this species, which we have shown can be done using a relatively simple data collection protocol. Involving the local community in the monitoring of the species may provide an opportunity for obtaining larger data sets while contributing to their engagement in the conservation of the Alaotran marshes.

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ARTICLE

L'exportation de bois précieux (*Dalbergia* et *Diospyros*) « illégaux » de Madagascar : 2009 et après ?

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RÉSUMÉ

L'exploitation illégale de bois de rose a connu une expansion forte en 2009 à la suite de deux arrêtés interministériels autorisant l'exportation de bois précieux. Les parcs nationaux ont été spécifiquement affectés par cette exploitation. Il est extrêmement difficile de connaître la situation réelle de l'exploitation mais aussi des exportations malgré les autorisations temporaires. Cet article présente et analyse des informations circulant sur ces exportations « illégales ». Il analyse également des solutions de régulation du trafic. Il fait plus particulièrement un parallèle entre la régulation du trafic d'ivoire et la régulation du trafic de bois précieux à Madagascar. Il conclut que la procédure de saisie avec revente par adjudication a peu de chances de s'avérer efficace. Comme le cas du trafic d'ivoire a montré que l'interdiction et la saisie ont plutôt pour effet de modifier les circuits du trafic plutôt que de le freiner, la seule solution envisageable à terme est le développement d'une filière certifiée en gestion durable pour les bois précieux. L'European Union Due Diligence Regulation et le Lacey Act aux États-Unis constituent des moyens de pression qui poussent à la création de ce type de filière.

ABSTRACT

Illegal rosewood logging has known a strong increase in 2009, following two interministerial texts legalizing exports of precious wood. National parks are specifically affected by this exploitation. It is of course very difficult to know the real situation concerning exploitation but also exports. This paper presents and discusses information about "illegal" exports. Firstly, after a recall of the legal context, it underlines the difficulties in collecting information. Several reasons are underlined: the size of container, the density of wood, the diversity of material (log, board, etc), the place of shipment, the filling up of containers, and under-declaration for fiscal reasons. Nevertheless, even if exports estimations are probably far from the reality, the equivalent of around 1,202 containers, representing a value of more than US $ 220,000,000 are listed. Secondly, it analyzes also traffic regulation systems. More specifically, it proposes a parallel between the regulation of ivory traffic and the regulation of precious wood traffic in Madagascar. It concludes that the process of garnishment with resale by auction has very few chances to be efficient. The ivory case shows that reinforcing processes of garnishment do not succeed in stopping the traffic. It rather provokes reorganisations of the value chain. In the long term, the sole solution will be the development of a sustainable labelled chain for precious wood. European Union Due Diligence Regulation and Lacey Act in United States participate in the strengthening of control on precious wood.

MOTS CLEFS : Bois de rose, *Dalbergia*, Madagascar, exportations.
KEYWORDS: Rosewood, *Dalbergia*, Madagascar, exports.

INTRODUCTION

Début 2009, Madagascar est entré dans une crise politique profonde associée à des troubles de l'ordre public qui ont duré jusqu'en avril. Dans ce contexte, une affaire a enflé durant l'année à propos des exportations de bois précieux (plus particulièrement les espèces des genres *Dalbergia* et *Diospyros*). Dans cette affaire, le terme « bois de rose » a été utilisé le plus souvent dans les médias. En réalité, le problème renvoie non seulement au bois de rose, mais aussi aux autres espèces de bois précieux comme l'ébène et le palissandre (concernées elles aussi par le trafic). Pour ce qui est du bois de rose, cette désignation commerciale concerne, en fait, quatre espèces particulières de palissandre du genre *Dalbergia.* Notons que 48 des 125 espèces de *Dalbergia* connues dans le monde ont été recensées à Madagascar. Les espèces d'ébène identifiées à Madagascar appartiennent toutes au genre *Diospyros* (Du Puy et al. 2002).

L'exploitation illégale de bois précieux n'est pas un phénomène nouveau à Madagascar (voir par exemple Patel 2007, Schuurman et Lowry II 2009, Randriamalala et Liu 2010), mais le problème a pris de l'ampleur et a été largement relayé dans la presse locale et internationale dans le courant de l'année 2009 à la suite d'exploitations dans les parcs nationaux. Par ailleurs, deux arrêtés interministériels autorisant à titre temporaire et exceptionnel l'exportation de bois précieux, un premier en début de l'année 2009, le second après la mi-année, ont provoqué de vives réactions. Dès le 30 avril de cette année, l'Observatoire National de l'Environnement et du

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Secteur Forestier – ONESF (2009a) publiait un bulletin d'alerte dans le journal L'Express de Madagascar pour sensibiliser la population et interpeller les responsables politiques sur la situation du bois précieux. Le 4 juin, la communauté internationale et les partenaires de la conservation résidants à Madagascar publiaient aussi un communiqué de presse indiquant leur préoccupation majeure face à la situation critique du bois de rose (Ambassade d'Allemagne et al. 2009). Le 3 octobre, les Organisations non Gouvernementales (ONG) World Wide Fund for Nature (WWF), Conservation International et Wildlife Conservation Society ont demandé au Gouvernement d'annuler l'autorisation d'exportation car elle « va à l'encontre des efforts déployés pour instaurer une bonne gouvernance environnementale et un système transparent de commercialisation du bois à tous les niveaux de la filière » (WWF et al. 2009). Le 6 octobre, la plateforme de la société civile œuvrant pour l'environnement, Alliance Voahary Gasy (2009) regroupant 27 organisations, a ainsi déclaré que l'autorisation exceptionnelle d'exportation de bois de rose « bafoue la législation forestière en vigueur » et qu'elle correspond clairement à un acte de « blanchiment de produits illicites et (de) généralisation de la corruption ». Un appel au boycott visant les importateurs des pays du Nord a été lancé par l'Alliance Voahary Gasy et Global Witness (2009) sous le titre « N'achetez pas des produits volés en provenance de Madagascar » et de nombreux communiqués de presse ont été publiés durant le mois d'octobre (par exemple dans le journal Les Nouvelles du 10 octobre 2009 par l'ONESF, ou encore toujours dans le même journal du 10 octobre 2009 par le parti vert malgache Hasin'i Madagasikara).

Considérant les exportations comme le ressort de l'exploitation illégale, et dans la mesure où d'une part elles représentent 98,5 % de la filière bois précieux à Madagascar (Rakotondramanga 2002) et d'autre part elles sont au cœur de l'affaire qui s'est développée en 2009, l'objet de cet article n'est pas d'examiner le phénomène de l'exploitation illégale de bois précieux en tant que tel, mais de présenter et analyser les informations sur les exportations recensées depuis le début de la crise, ainsi que de proposer des solutions au problème des exportations illégales. Nous rappelons dans une première section le contexte juridique. Dans une seconde section, nous soulignons le problème du manque d'information. Dans une troisième section nous faisons un état des lieux des informations sur les exportations et analysons les problèmes d'évaluation de ces exportations. Enfin, en quatrième section, nous discutons des solutions au problème.

CONTEXTE JURIDIQUE

Les soubresauts et changements dans la législation forestière concernant les bois précieux sont anciens à Madagascar et remontent au moins aux années 1970 (Randriamalala et Liu 2010). Mais depuis l'arrêté interministériel 11-832 / 2000 du 30 avril 2000, l'exportation du bois d'ébène et du bois de rose sous forme de grume est interdite. Seules les exportations de bois travaillé et semi travaillé sont autorisées. Cette interdiction a été confirmée à de multiples reprises, notamment par l'arrêté interministériel 17-939 / 2004 du 21 septembre 2004 et l'arrêté interministériel 16-030 / 2006 du 14 septembre 2006. Ce dernier article interdit même l'exploitation du bois de rose et d'ébène. Aucun élément nouveau depuis cette date, dans la réglementation forestière, n'est venu autoriser l'exploitation ou la collecte de bois précieux. En 2007, l'arrêté interministériel 10-885 / 2007 du 3 juillet 2007, vient même préciser, dans son article premier, que « L'exploitation de bois de forêts naturelles, toutes catégories confondues, à l'état brut et semi travaillé, est interdite ». Cependant, cette législation présente une certaine ambiguïté dans la mesure où elle autorise l'exportation du bois de rose, de l'ébène et du palissandre sous forme de produits finis. Il paraît en effet étrange de pouvoir exporter du bois, même sous forme de produits finis, dont l'exploitation est interdite. Une ambiguïté similaire se retrouve au cœur de l'affaire qui se développe au cours de l'année 2009.

Alors qu'une véritable crise politique et des troubles à l'ordre public débutent le 26 janvier 2009, dès le 28 janvier un décret interministériel (n°003 / 2009) autorise, temporairement jusqu'au 30 mars 2009, l'exportation de bois précieux découpés, et ce pour 13 opérateurs. Le 21 septembre un nouvel arrêté interministériel (n°38244 / 2009) autorise l'exportation de bois précieux bruts pour une période courant jusqu'au 30 novembre pour les mêmes 13 opérateurs. Ce dernier arrêté autorise un quota de 25 conteneurs par opérateur contre paiement de 72 millions d'ariary par conteneur, soit l'équivalent de 36 000 US $ par conteneur. Ces deux arrêtés fournissent une autorisation exceptionnelle d'exportation pour des bois précieux alors que leur exploitation reste illégale (Ravaloson 2009). Nous retrouvons la même ambiguïté qu'en 2006. Néanmoins, cette fois l'autorisation d'exportation ne concerne pas seulement des produits finis mais également des rondins bruts. Face aux réactions suscitées par ces textes législatifs, l'arrêté n°38409 / 2009 du 5 octobre 2009 est venu confirmer et compléter les dispositions de l'arrêté n°38244 / 2009, en précisant notamment que les exportateurs sont tenus de déclarer la provenance, la nature, la quantité et la qualité des produits. Cependant, ce nouvel arrêté ne change rien sur le fond du problème. Pour cette raison, le 19 novembre l'Alliance Voahary Gasy a déposé un recours en annulation de l'arrêté du 21 septembre devant la juridiction compétente, afin que ce type de procédé ne se reproduise plus. Jusqu'à présent, ce recours n'a pas eu de suite.

Le 31 décembre 2009, le premier ministre Camille Vital publiait une note de service autorisant les opérateurs remplissant les conditions d'exportation et qui n'avaient pas pu exporter au terme du délai imposé par l'arrêté du 21 septembre (le 30 novembre) à le faire. Les coupes illicites ont continué (Rakotomalala 2010a). Les partenaires internationaux ont alors publié un communiqué de presse demandant au Gouvernement de prendre des mesures pour faire cesser les coupes illicites de bois précieux (Ambassade des États-Unis et al. 2010). Face à la pression internationale, le premier ministre Camille Vital a, par décret n°2010-141 du 24 mars 2010, interdit toute exploitation et exportation de bois précieux. Ce décret n'a en fait guère de sens puisque, de fait, les arrêtés autorisant exceptionnellement les exportations de bois précieux ont pris fin et les décrets et arrêtés antérieurs interdisant l'exportation et l'exploitation restent valables. Il s'agissait donc clairement d'émettre un signal en direction de la communauté internationale. Les exportations de bois précieux ont néanmoins continué, comme en témoigne un cargo intercepté aux Comores avec 300 tonnes de bois de rose en juin (Nono 2010).

DIFFICULTÉS D'ACCÈS AUX INFORMATIONS ET MANQUE DE TRANSPARENCE SUR LES BOIS PRÉCIEUX

L'ampleur présumée de l'exploitation et des exportations de bois précieux depuis 2009 a provoqué beaucoup de réactions aux niveaux national et international : le Congrès américain a adopté une résolution condamnant l'exploitation illégale de bois de rose à Madagascar le 4 novembre (résolution 839). Face à la pression de la communauté internationale, le Gouvernement malgache a pris des mesures afin de signaler qu'il se préoccupe du problème. Ainsi, le port de Vohemar dans le nord-est du pays a été fermé, une *task force* pour arrêter l'exploitation et saisir le bois coupé a été mise en place. L'action du Gouvernement tente de répondre aux pressions étrangères et de la société civile malgache tout en maintenant l'ambiguïté entre exportation et exploitation. Les mesures prises visent en effet à freiner l'exploitation illégale tandis que, parallèlement, des exportateurs qui ont rempli les conditions des arrêtés publiés en 2009 peuvent continuer à exporter. Cette ambiguïté est amplifiée par la faible qualité de l'information disponible. Par qualité, nous entendons surtout la fiabilité des informations (par exemple la quantité d'arbres coupés, la quantité de bois exporté, les aires ou zones touchées) et leur accessibilité (rapports validés et publiés par des acteurs directement concernés, informations officielles). Or, il est évident que la bonne qualité des informations est importante pour évaluer la situation. Sans une information fiable, les rondins bruts de bois précieux exportés sont déclarés comme des coupes antérieures, des stocks détenus depuis plusieurs années à la suite de cyclones et non comme des rondins fraîchement coupés. Or les rondins stockés depuis plusieurs années ne sont pas sujets à sanction pour exploitation illégale et sont de fait exportables selon les arrêtés de janvier et septembre 2009. Fin 2003, le cyclone Gafilo touchait la Région SAVA (région nord-est de Madagascar). Déjà un arrêté interministériel ordonnait début 2004 l'autorisation temporaire, jusque fin mars 2004, de l'exploitation et de l'exportation de grumes de bois précieux, uniquement pour les arbres abattus par le cyclone. Cette autorisation a constitué une porte ouverte au développement de l'exploitation illégale. Il est en effet très difficile de manière pratique de savoir si le bois pour lequel un permis est demandé temporairement a vraiment été abattu par le cyclone où s'il a été abattu après le cyclone. Il est par ailleurs très difficile de connaître avec exactitude les endroits où les arbres ont été abattus. Le cyclone n'aurait en réalité pas touché les bois précieux, ou de manière extrêmement réduite, ne justifiant pas un tel arrêté. Les arbres abattus par le cyclone étaient des papayers et des cocotiers principalement (point de vue exprimé par le directeur du Parc National de Marojejy, cité par Patel 2007). Randriamalala et Liu (2010) soulignent « qu'étrangement » les cyclones semblent affecter spécifiquement les bois précieux puisque comparativement ils sont plus souvent déclarés abattus par les cyclones que les autres arbres, alors même qu'ils sont moins nombreux. À partir de cet arrêté, les stocks de bois précieux concernés sont devenus élastiques, et l'exploitation illégale s'est amplifiée (Rasarely et al. 2005).

Depuis 2009, les bois précieux écoulés seraient toujours des stocks constitués à la suite de cyclones. Chaque nouvel arrêté autorisant l'exportation joue de l'ambiguïté entre exploitation et exportation grâce à l'absence d'information, favorisant l'exploitation illégale, en considérant que les bois exportés sont issus des stocks antérieurs. En ce sens, l'information sur les stocks antérieurs, mais aussi sur les bois précieux dans les zones forestières est cruciale puisqu'elle permettrait clairement d'établir l'origine des bois. Mais la quantité existante de la matière première, les bois précieux, qui se trouve dans les forêts, est mal connue. Elle est d'autant plus mal connue que la surface forestière de Madagascar est elle-même très mal connue. Mercier (1991) citant un ancien directeur des Eaux et Forêts, M. Rakotomanampison, souligne que les informations disponibles oscillent entre une surface de 0,5 million d'hectares et 10 millions d'hectares ! Des inventaires forestiers qui donneraient les informations recherchées sont peu nombreux, difficiles d'accès, anciens ou difficiles à comparer pour permettre d'avancer des chiffres fiables sur les stocks de bois sur pied en forêt. Le manque de données sur la production et la croissance des espèces forestières concernées est une seconde difficulté. En raison de la complexité du phénomène de renouvellement et de la quasi-inexistence de recherches scientifiques sur cette question, les scientifiques et les forestiers ne sont pas en mesure d'estimer la capacité de régénération pour ces espèces et ainsi ne peuvent pas établir des plans d'aménagement forestier susceptibles d'assurer une durabilité de la production du bois. Il en résulte que ni les quantités réelles des arbres abattus ni leurs lieux d'exploitation ne sont connus. Les filières illégales jouent de cette absence d'information. Quand le Gouvernement a publié les textes permettant l'exportation de ces bois (cf. supra) le chiffre officiel de 325 conteneurs autorisés a été donné (arrêté de septembre). Mais les quantités exactes de bois ne peuvent malgré tout pas être estimées avec précision puisque les textes ont mélangé les trois principales catégories de bois précieux (bois d'ébène, bois de rose et autres palissandres). Par ailleurs, les arrêtés interministériels sur l'exportation du bois n'imposent aux acteurs impliqués dans l'exportation et l'importation (à l'étranger) aucune obligation d'exposer leurs informations concernant l'activité commerciale (quantités précises, valeurs, destinations, clients). L'administration forestière elle-même, en exerçant son rôle régalien, n'a pas le devoir de publier les rapports de ses missions de contrôle. Il en est de même pour des rapports internes des institutions directement touchées par les exploitations, tel que les gestionnaires des aires protégées. L'ONESF, qui est par contre « un organe autonome et indépendant pour la collecte et l'analyse des informations, un outil de veille d'information, de mobilisation » n'a pas diffusé non plus d'information quantitative sur son site web par rapport à la problématique du bois précieux en 2009 (<http://www.osf.mg/index.php>). Il semble donc, au regard de ces éléments, que les autorités n'ont rien fait pour améliorer l'information sur les bois précieux. Dans les paragraphes suivants, en utilisant les sources d'information qui nous paraissent les plus fiables, nous discutons des exportations de bois précieux depuis 2009. Les données que nous utilisons ne proviennent pas de sources ayant procédé par un protocole scientifique de collecte d'information. Ce sont des données secondaires issues d'investigations de type journalistique, et doivent donc être prises avec précaution. Néanmoins, il s'agit des seules sources d'informations disponibles sur le sujet. Par ailleurs, il ne s'agit pas ici de fournir un volume réellement exporté, ni une valeur des exportations, mais de faire un état des informations disponibles et de les analyser. Notons toutefois que parmi ces sources d'information, deux études fournissent des informations de haute qualité.

La première est l'étude réalisée par Global Witness (GW) et Environmental Investigation Agency (EIA) en 2009. Suite aux exploitations massives et persistantes dans les parcs nationaux (notamment Masoala, Marojejy et Mananara-Nord) depuis le début de la crise politique, une mission d'investigation conjointe de GW et EIA demandée par Madagascar National Parks et avec l'accord du Ministre de l'Environnement et des Forêts, M. Mariot Rakotovao, a été réalisée en juillet-août 2009 sur le terrain dans les parcs nationaux de Marojejy et de Masoala. Les observations de terrain ont été complétées par l'accès à un ensemble de documents administratifs tels que les documents de douane, ceux des services des eaux et forêts, des informations bancaires, etc. La seconde est l'étude réalisée par Randriamalala et Liu (2010) d'une durée d'un an (février 2009 à février 2010). Cette étude s'est fondée sur la collecte de documents administratifs et d'informations recoupées auprès de nombreuses personnes. Notons que ces deux études ne sont pas totalement différentes. L'étude de Randriamalala et Liu (2010) se réfère aussi à celle de GW et EIA. Elles doivent donc être perçues comme complémentaires. Elles ne portent pas sur la même période, la seconde étant plus large que la première.

UN ÉTAT DES LIEUX

ZONES D'EXPLOITATION ILLÉGALE. Il est évidemment difficile de déterminer l'origine exacte du bois exporté. Une partie vient probablement de stocks antérieurs qui ont été laissés en forêt, mis dans des fosses dans le sable ou ont été cachés… Ainsi, le dépôt de bois du service des Eaux et Forêts d'Antalaha, où sont entreposés les bois illégaux saisis a été attaqué et dévalisé le 26 janvier par la « mafia » du bois (Débois 2009). Mais une autre partie provient de nouvelles coupes. Les parcs de Masoala et de Marojejy ont ainsi été investis par les bûcherons avec l'aide des trafiquants. Ceux qui s'y sont opposés ont été menacés. Le 8 février 2009, les trafiquants ont dispersé par des tirs d'armes automatiques la population venue protester contre le chargement de billes de bois du parc de Marojejy. Le directeur du parc a été menacé et a décidé de fermer le parc au public. Une véritable ruée vers le *bolabola* (terme malgache pour désigner les rondins de bois précieux) a alors eu lieu. Les habitants des alentours des parcs y ont participé eux aussi (Débois 2009).

L'exploitation illégale semble se concentrer sur des zones spécifiques, à savoir les aires protégées de la région SAVA (située au nord-est de Madagascar) et des proches environs : Marojejy, Masoala, Makira et Mananara-Nord. De nombreux témoignages rapportent en effet depuis plusieurs années que les bois proviennent en grande majorité de ces zones (par exemple Raoel 2005, Rasarely et al. 2005, Blondel et Haja 2006, Patel 2007, Blondel et Haja 2008, GW & EIA 2009). À titre d'illustration, en 2009, GW et EIA indiquent que les patrouilles de gendarmerie et les agents du parc de Masoala ont recensé 142 campements de bûcherons dans le parc. Mais des informations circulent concernant d'autres régions hors de la SAVA où des exploitations illégales semblent augmenter. La concentration sur les aires protégées s'expliquerait par le fait que les zones situées aux alentours de ces parcs ont déjà subi une exploitation excessive par le passé (Patel 2007).

LES VOLUMES CONCERNÉS. Au total, au moins 1187 conteneurs auraient été exportés (Randriamalala et Liu 2010) et 1500 autres seraient répertoriés, mais n'auraient pas encore été exportés. Il est en outre très difficile de connaître le tonnage représenté par ces conteneurs et ce pour au moins six raisons. La première tient au fait que les conteneurs peuvent être soit des conteneurs de 20 pieds, soit des conteneurs de 40 pieds donc avec un volume et un tonnage qui varient du simple au double. Par ailleurs, même si des informations sont disponibles sur un des éléments, le tonnage ou le volume, transformer l'un en l'autre suppose de formuler une hypothèse de densité. Par exemple, Randriamalala et Liu (2010) ont considéré une densité moyenne de 1,02. La densité est en fait très variable selon les espèces. La densité du bois de rose est inférieure à celle de l'ébène. Aussi, la seconde raison tient au fait qu'il faut connaître les espèces contenues dans le conteneur. Or les informations sur les espèces contenues dans les cargaisons sont encore plus opaques que celles sur les conteneurs. Randriamalala et Liu (2010) notent que sur les exportations qu'ils ont recensées, 0,7 % des bois étaient de l'ébène seulement. Ce qui justifie une hypothèse de densité relativement proche de 1. Troisièmement, les conteneurs sont chargés de matériaux divers (rondins, planches), au delà des espèces. Ainsi, GW et EIA (2009) soulignent à partir de relevés dans des conteneurs que la variabilité du contenu est très forte. Les conteneurs de rondins contiennent entre 30 et 274 rondins, tandis que des conteneurs de planches en comprenaient entre 49 et 1055. Cette variabilité n'est pas due au niveau de remplissage mais aux gabarits des matériaux non standardisés. Les conteneurs examinés étaient remplis. Or évidemment, la charge d'un conteneur est très dépendante de la capacité d'empilement, elle-même relative aux types de matériaux. Quatrièmement, le lieu de chargement est très important. Le port de Vohemar possède un engin de levage qui ne peut soulever une charge supérieure à 20 tonnes, tandis que le port de Toamasina n'a pas cette restriction. À Vohemar des conteneurs de 20 pieds pour un poids maximum de 20 tonnes peuvent être embarqués, tandis qu'à Toamasina des conteneurs de 40 pieds pouvant atteindre un poids de 65 tonnes peuvent être chargés et ceux de 20 pieds peuvent atteindre 32 tonnes (Randriamalala et Liu 2010). Cinquièmement, considérant que les exportateurs sont soumis à une double pression en matière de chargement, avec, d'une part la volonté d'exporter au plus vite ce qui peut l'être, et d'autre part la volonté de maximiser le contenu d'un conteneur, nous pouvons considérer qu'un conteneur exporté n'est pas nécessairement plein. Enfin, sixièmement, les estimations réalisées à partir de données fournies par des documents administratifs de douane sous-estiment généralement le poids. En effet, lors du chargement au port, la douane vérifie le nombre de rondins ou planches dans les conteneurs mais pas le tonnage. Celui-ci est déclaré par l'exportateur avec le nombre de rondins et de planches. Or, comme les diverses taxes de port et d'exportation, puis d'importation, sont payées en fonction du tonnage, le risque de sous-déclaration du tonnage est important (Randriamalala et Liu 2010). Pour toutes ces raisons, les chiffres d'exportation de bois précieux estimés sont à prendre avec beaucoup de précaution. Randriamalala et Liu (2010) estiment malgré tout que les 1 187 conteneurs qu'ils ont recensés représentent environ 36 730 tonnes. En utilisant ce total et en ajoutant les 300 tonnes saisies aux Comores (Nono 2010), nous obtenons un poids total d'environ 37 030 tonnes. Ces chiffres, déjà conséquents, prennent toute leur signification quand on sait que la quantité moyenne de bois précieux officiellement exportée était de 1 204 m^3 / an entre 2000 et 2005 (Rahaga 2006)

(soit 12 280 tonnes environ, avec une densité de 1,02). Depuis 2005, le trafic semble s'être cependant largement amplifié. Les statistiques des douanes de la République populaire de Chine obtenues par GW et EIA (2009) indiquent qu'entre 2005 et 2008 compris, 13 192 m^3 (environ 13 450 tonnes) ont été recensés pour ce seul pays ; ce chiffre sous-estimant certainement la réalité des exportations vers ce pays en raison des produits non déclarés. Randriamalala et Liu (2010) indiquent que les douanes chinoises ont recensé officiellement 1000 tonnes de bois importées sous forme de rondins en provenance de Madagascar dans le pays en 2008. De plus ces 1000 tonnes correspondent à un ensemble de rondins sans qu'il soit possible de dire de quel type de bois il s'agit. Mais ils soulignent que le tonnage effectif exporté par Madagascar cette même année serait de 14 000 tonnes et que la Chine est le principal importateur (plus de 90 % des exportations de bois précieux de Madagascar iraient vers ce pays). Un tel constat indique donc qu'un facteur 10 entre la réalité et les chiffres officiels pourrait exister !

QUELLE VALEUR ? La question de la valeur des bois exportés est certainement une des plus délicates et ce pour deux raisons. D'une part, la valeur dépend des espèces réellement exportées ; or il n'existe pas de distinctions statistiques précises et toutes les espèces sont regroupées sous la même appellation au niveau des douanes : « autres produits forestiers ». D'autre part, les valeurs déclarées peuvent être sous-estimées. Les chiffres pour des valeurs en bout de filière, à l'exportation, concernant des grumes ou des planches brutes non standardisées, varient fortement selon les sources d'information. GW et EIA (2009) indiquent que des prix officiels variant entre 3000 et 4000 US $ par m^3 sont pratiqués pour des exportations vers la Chine. Ce rapport fait également état d'un prix moyen officiel selon les statistiques douanières de 3 395 dollars (US $) par m^3 pour des exportations vers la Chine entre 2005 et 2008. Randriamalala et Liu (2010) estiment des prix de 5 à 6 US $ le kg, soit entre 5500 et 6600 US $ par m^3. Patel (2007) faisait déjà état d'un prix de marché à l'exportation de 7 US $ / kg pour le bois de rose. Sur le marché américain, une pièce de bois sous forme de planche brute non travaillée se négocie aux alentours de 7,5 US $ le kg (soit 8 300 US $ le m^3). À titre d'exemple, sur le site <http://www.hearnehardwoods.com>, une pièce de bois de rose de Madagascar (*Dalbergia maritima*), d'une dimension de 248,92cm x 11,43cm x 7,62cm est vendu à 180 US $. Ce qui revient à peu près à 8300 US $ / m^3, soit environ 7,5 US $ le kg. Étant donné que les prix officiels relevés dans les statistiques douanières en Chine sont certainement sous-évalués par rapport à la valeur réelle payée et que le prix de revente de bois brut sous forme de planches semble se situer aux alentours de 8 000 US $ le m^3, les prix estimés à Madagascar, compris entre 5 et 6 US $ le kg pour des rondins, semblent fournir un bon ordre de grandeur. Il reste néanmoins extrêmement difficile de connaître le prix exact des conteneurs, pas seulement parce que les déclarations ne correspondent pas nécessairement à la réalité des transactions, mais aussi parce que la valeur des conteneurs dépend étroitement de leur contenu en termes de type de bois (bois de rose, ébène) mais aussi du type de matériaux (grume, planche). Pour 6 US $ par kg, les 37 030 tonnes indiquées ci-dessus représenteraient une valeur de 222 180 000 US $ à l'exportation au départ de Madagascar. Les sommes colossales en jeu incitent évidemment au trafic. Dans de telles circonstances, quelles solutions sont envisageables pour l'enrayer ?

QUELLES SOLUTIONS ?

L'exploitation illégale de bois précieux continuera à Madagascar tant que les exportateurs pourront écouler le bois coupé illégalement. Différentes solutions peuvent être envisagées pour enrayer ce phénomène. Actuellement deux points de vue s'opposent au sein des Organisations Non Gouvernementales de protection de la nature et des bailleurs de fonds, mais également au sein de la société civile malgache.

Le premier consiste à appliquer la procédure légale actuelle. Elle suppose la saisie du bois et sa revente par adjudication au profit de l'État. Le décret ministériel 2001-068 fixant les modalités de vente des produits forestiers saisis ou confisqués ne prévoit pas que l'ancien « propriétaire » ne puisse pas se porter soumissionnaire pour le rachat de ce bois. Cependant, l'arrêté 13855 / 2001 portant approbation du cahier des charges et prescriptions générales relatives à l'octroi de permis par voie d'adjudication est venu compléter ce décret en indiquant que les personnes ayant commis des délits forestiers doivent être exclus de la procédure d'offre par la commission forestière chargée de l'adjudication. Cette disposition exclut en principe les anciens propriétaires des bois saisis. Mais cela ne les empêche pas de passer par un « prête-nom », notamment grâce à la collusion pratiquée entre trafiquants. Si le coût est plus élevé pour eux, ils peuvent répercuter ce supplément de coût, au moins en partie, sur le prix de marché. La demande mondiale correspond en effet à des usages spécifiques (instruments de musique, meubles, etc.) difficiles à modifier rapidement en raison d'une demande sociale forte dans les pays d'importation. Elle paraît suffisamment forte pour que l'augmentation du prix ne conduise pas à une baisse significative de la demande. Ainsi par exemple, sur le site web <http://www.exoticwood.biz/boisderose.htm>, on pouvait lire : "Current conditions in Madagascar mean that this wood will become unavailable, as all exports have apparently stopped permanently. We have bought more of this wood from old stocks, but we are now paying higher prices as the supply tightens." (consulté le 1 novembre 2009). Par ailleurs, Randriamalala et Liu (2010) soulignent que la taxe de 72 millions d'ariary (36 000 US $) prévue par l'arrêté du 21 septembre par conteneur, a été payée dans un bon nombre de cas par les importateurs chinois. Ce qui indique clairement que le prix de marché peut croître encore. On peut donc penser qu'étant donnée la rareté du bois par rapport à la demande, une augmentation de prix devrait être absorbée par le marché. La revente par adjudication risque fort alors de ne pas réellement freiner le trafic de bois précieux. Selon les détracteurs de cette solution, elle aurait plutôt tendance à légaliser du bois illégal. Cette procédure n'a d'ailleurs quasiment pas été utilisée et n'a abouti qu'à une vente fermée, au profit exclusif d'un officiel haut placé (communication d'un rapporteur anonyme de la revue). L'avantage de la revente par adjudication est qu'elle incite l'État à agir puisqu'il est le premier bénéficiaire de la saisie. Les reventes permettent éventuellement de financer les mesures répressives. Et en ce sens, la vente par adjudication crée une incitation économique à la sanction contre l'exploitation illicite. Notons toutefois que si la revente par adjudication crée une incitation pour l'État à sanctionner, elle ne crée pas nécessairement une incitation à arrêter l'exploitation illégale. Il est en effet plus rationnel d'un point de vue purement monétaire de laisser s'exercer l'exploitation illégale et de sanctionner ensuite en saisissant le bois, car c'est dans ce seul cas de figure que l'État peut collecter un gain.

La seconde solution consiste à saisir le bois et à le brûler. Cette solution est symboliquement forte et répond à la limite précédente émise à l'encontre de la revente par adjudication. Le fait de brûler le bois ne produit aucune incitation économique pour l'État qui supporte l'ensemble des coûts inhérents aux contrôles et aux sanctions mais ne reçoit rien en contrepartie. Une telle solution présente évidemment des objections. Premièrement, du fait de sa densité, ces bois précieux sont difficiles à brûler. Deuxièmement, cela supposerait éventuellement de les regrouper pour les brûler, ce qui coûterait cher. Troisièmement, un tel acte pourrait aussi apparaître totalement démesuré, étant données les sommes en jeu, dans un pays aussi pauvre que Madagascar. Enfin, quatrièmement, d'un point de vue écologique, il s'agirait d'un acte assez négatif puisque le fait de brûler le bois provoquerait une libération du carbone. Il nous semble néanmoins que ces quatre objections ne sont pas si fortes que cela. En effet, le trafic d'ivoire a subi les mêmes critiques et pourtant la solution adoptée a bien été de brûler les stocks saisis au fur et à mesure. Il n'est point besoin de les regrouper pour cela et ils peuvent brûler directement sur place.

Ces deux solutions ont donc des limites. Du fait du parallèle possible avec le trafic d'ivoire, il est intéressant de s'interroger sur leur potentiel de régulation du trafic à partir d'un regard rétrospectif sur ce cas. Le marché de l'ivoire était libre jusqu'en 1989, avec cependant un système de quotas depuis 1986. À partir de 1989, la prohibition totale du commerce d'ivoire a été décidée (Kaempfer et Lowenberg 1999). Les éléphants ont été classés espèces en danger par la Convention internationale sur le commerce des espèces de faune et flore sauvages en danger (CITES). Dans un bon nombre de cas, l'ivoire saisi était brûlé. Même si les estimations sont à prendre avec beaucoup de précaution, dans la mesure où elles résultent des saisies réalisées et ne mesurent effectivement que ce qui peut être comptabilisé du trafic, elles montrent que le nombre de saisies a chuté sensiblement à partir de 1990 pour ensuite remonter à partir de 1995 jusqu'à la fin des années quatre-vingt-dix (CITES 2007). À partir de 1997, plusieurs pays ont exercé des pressions pour pouvoir maintenir un commerce de l'ivoire sur le marché local. En 1999, trois ventes publiques exceptionnelles ont été décidées à la suite de la décision 10-1 de la 10^{e} Conférence des parties à la CITES. Ces ventes exceptionnelles ont eu lieu en Namibie, au Zimbabwe et au Botswana en avril 1999. Cependant, cette remontée des saisies s'explique essentiellement par le développement de marchés locaux (Lemieux et Clarke 2009). Le nombre de saisies comme les tonnages saisis sont restés relativement stables dans le temps entre 1999 et 2005, aux fluctuations annuelles près. Mais une remontée des saisies est observée depuis 2005 et les pressions se multiplient, notamment de la part des pays du sud de l'Afrique, pour faire valoir le maintien du commerce local (CITES 2007, McCarthy 2010). Les tonnages saisis restent eux stables. Ainsi, sur toute la période, le nombre de tonnes saisies n'a pas changé significativement.

Ces résultats soulignent que l'interdiction complète, assortie de la destruction des stocks saisis, n'a pas modifié radicalement le volume du trafic. En revanche, le fait que le nombre de saisies ait diminué dans un premier temps puis repris avec le développement de marchés locaux, semble indiquer que la régulation a un effet sur la structure du marché. En particulier, l'interdiction complète a pour effet de supprimer les petites filières. Le trafic s'organise alors autour de grandes filières professionnelles. Le développement des marchés locaux a, au contraire, pour effet de permettre la diversification des chemins d'exportation et de démultiplier les envois de plus petits volumes, sans pour autant que l'on puisse considérer que les volumes globaux exportés soient significativement modifiés. Au total, la régulation a un effet sur la structuration des filières mais pas sur les volumes exportés (Lemieux et Clarke 2009). Dans le cas des bois, il semble que la procédure par adjudication ne soit pas comparativement moins efficace que dans le cas de l'ivoire, au moins parce qu'elle crée une incitation pour l'État d'agir. Cependant, comme nous l'avons indiqué, elle a aussi de fortes chances de s'avérer très insuffisante si le renchérissement du coût pour les trafiquants est absorbé par le marché. Face aux limites des procédures de saisie, il apparaît urgent de trouver une solution alternative. Il nous semble que le développement d'une filière « certifiée » constitue la voie de sortie de l'exploitation illégale la plus sérieuse. À moyen terme, le développement d'une telle filière pourrait s'avérer une solution avantageuse pour détourner les opérateurs des filières illégales. Elle pourrait également être avantageuse pour l'État grâce à la mise en œuvre d'une taxation spécifique sur le bois précieux. Il ne s'agit, en fait, pas seulement d'une solution intéressante, mais d'une voie de plus en plus incontournable. Les conditions d'accès au marché de l'Union Européenne pour les bois sont en cours de redéfinition à travers l'European Union Due Diligence Regulation (Commission of the European Communities 2008), imposant une traçabilité sur la légalité des bois importés. Aux États-Unis, le Lacey Act (EIA 2007) interdit désormais l'importation de bois d'origine illicite. Dans un tel contexte, l'État malgache devrait s'engager plus positivement dans le dispositif FLEGT (Forest Law Enforcement, Governance and Trade) engagé par la Communauté européenne pour aider les pays à renforcer leurs capacités de contrôle des exploitations et du commerce illicites de bois (Commission Européenne 2007). Ces nouvelles régulations du marché international du bois obligeront à développer des systèmes d'informations sur les filières, ce qui finalement devrait faciliter le contrôle de filières illégales. Il reste néanmoins difficile de penser sérieusement l'existence d'une telle filière actuellement, du fait de son illégalité et du fonctionnement très informel qui y prévaut. Il s'agit donc d'un enjeu majeur pour Madagascar, qui déborde du cas du trafic de bois précieux.

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INTERVIEW MADAGASCAR CONSERVATION & DEVELOPMENT

Social science and conservation in Madagascar

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CHRISTIAN A. KULL, Monash University, Australia

Can you start by telling us something about your experience and research / work in Madagascar, and how you perceive the role of social science in conservation on the island?

Social science research in Madagascar is like that anywhere on this planet. It involves scholars asking questions about society in all its complexity, and through some structured mode of rational enquiry (be it theoretical, quantitative, experiential, descriptive, or other). Scholars from within and outside Madagascar have over the past century contributed to a solid body of research investigating Malagasy society, including its interactions with the plants, animals, soils, and waters around it. Since the late 1980s, the environment, and in particular nature conservation, have been an important (at times even dominant) focus for foreign-funded projects and institutions. Unsurprisingly, as a result, a sizeable portion of recent social science research has focused on protected areas, forests, and their peripheries. Sometimes this reflects the agendas of conservation institutions sponsoring research in the communities with which they interact; sometimes it is a marriage of convenience in which a researcher gains access to logistical support (four-wheel drive transport, housing, contacts); sometimes it is because a social science researcher wants to address the 'biggest show in town'.

My own work on Madagascar (on land use change, fire, parks, and introduced trees) has not been affiliated with conservation organizations, though I frequently interacted with particular institutions or individuals as the opportunity arose. In particular, my stint as a 'programme assistant' at WWF International's headquarters in 1992 heavily influenced what I saw and how I interpreted it on my first visit to the island (as a backpacking tourist) that year. In later years, I benefitted from valuable, yet informal, logistical support from WWF in visits to Andapa and Andringitra. It is no accident that my later institutional affiliation at the University of Antananarivo has been through ESSA-Forêts (*Ecole Supérieure des Sciences Agronomiques, Département des Eaux et Forêts*), as opposed to the *Laboratoire de Géographie*, despite being a geographer, for the former appeared more active, more connected, more experienced in hosting foreign researchers, largely from its involvement in various forestry and environment initiatives.

I don't perceive there to be a systemic problem with the role of social science in conservation on the island, though there are of course instances of conflict or misunderstanding. The more critical problem as I see it is one of political economy, between the conservation lobby and local people (and one shouldn't necessarily conflate natural scientists with the former and social scientists with the latter, nor paint any of these groups too starkly). In general, however, the conservationists have money, hence power; the locals have their axes and spades, but little voice. If locals had secure control of their lands within a robust political system, imagine how different negotiations over conservation restrictions would be.

In your opinion how could the social science research carried out in Madagascar be better adapted to, and used more effectively for, informing conservation policies?

It must be recognized that there are a wide diversity of social science research approaches and agendas, and that many of these have engaged with the topic of conservation globally for at least two decades (see for example, reviews of the fields of 'political ecology' or 'common-property theory' and others in Robbins et al. 2010). Some work will be specific and adaptable to field practitioners; other work will be more conceptual or critical, and both have their role to play. Given that many social scientists come to research topics related to conservation with what could be termed 'red and green' views, or ideological commitments to both social justice and environmental conservation, I wouldn't necessarily seek to change how social science research is carried out in a top-down way, but seek to increase spaces for interaction between social scientists, natural scientists, and conservation practitioners (see last question).

Is socially equitable conservation a myth? How could it be achieved in Madagascar?

Socially equitable conservation is a great slogan, but also a myth. However it is true that some forms of conservation may be more socially equitable, or less unjust, than others. Most actions to manage natural resources, whether in a single crop field or across a continent, create both winners and losers at different temporal and spatial scales. Such actions include, for example, the legislation of a fire ban, the building of a dam, the cultivation of a new crop, the creation of a protected area, or the designation of fishing rights. Proponents of change dress actions up as 'for the common good', or 'for future generations',

or as morally 'the right thing to do', but it is unusual that someone's interests are not stepped upon. This is where a society, through legitimate political processes, should make a decision. This happens all the time – the Parliament of Victoria (home to my university), debated at length in 2005 the decision to restrict cattle grazing in alpine grasslands; or in several indigenous villages in Fiji (where I currently live) the chiefs, after deliberations with their constituencies, put in place marine reserves in their fishing grounds in the past decade. The problem with conservation in Madagascar is that local communities have, in general, not had much voice. This reflects the weak political structures in this post-colonial, frequently instable polity, the stark divides between town and country, and the lack of bottom-up social activism (compare, for example, Latin America or parts of south and southeast Asia). But it also reflects the strong position of conservation actors, shaped by the country's poverty, its status as a biodiversity hotspot, and the funding constraints of donors like USAID (United States Agency for International Development) (Corson 2010) or AFD (*Agence Française de Développement*). The result is conservation decisions that are rarely fully legitimate to the people most affected by them. As Freudenberger's (2010) review of 25 years of USAID interventions suggests, governance is crucial.

How do you think the contrasting views on the ethics, concepts and impacts of conservation in Madagascar can be reconciled? Who should be doing what?

One cannot expect people who hold different worldviews to change; the world would be poorer without its diversity of views and ideas. However, there are ways to open up space for more constructive dialogue, to avoid the trading of insults across a wide *lavaka* gully. If studies of conflict resolution are anything to go by, compromise and positive interactions (if not agreement) come largely through proximity and engagement. The more social scientists that have taken a class in biology, and vice-versa, the better. The more research teams that assemble truly multidisciplinary groups of scientists the better – helping each other in fieldwork, sharing stories in the evenings, forging reports together. The more integrative meetings, goal-setting workshops, and so on, the better. And all of this should be rooted in a specific geographic context, a place, a community in which people engage and hold some responsibility for their words and actions. And finally, a stronger civil society and governance structure would hold both academic 'sides', as well as conservation actors, better to account in delivering a more socially just and environmentally sustainable future.

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ALAIN BERTRAND, Edenia Consult Tanja, France

Pouvez-vous commencer par nous dire quelque chose sur votre expérience et la recherche / le travail que vous effectuez à Madagascar et comment vous voyez les sciences humaines et sociales dans la protection de la nature à Madagascar ?

J'ai été impliqué directement de 1994 à 1998 dans le processus collectif d'émergence et de mise en place institutionnelle de la gestion communautaire locale des ressources renouvelables à travers la loi 96-025 dite loi GELOSE (i.e. gestion locale sécurisée). Dès cette époque avec divers scientifiques et universitaires malgaches (par exemple feu Mamy Razafindrabe, sociologue) nous avons insisté sur la nécessaire prise en compte de la multiplicité et de la diversité des situations locales. C'est pourquoi la loi GELOSE est simplement une loi-cadre fixant un minimum de règles et de procédures avec une grande liberté d'adaptation selon les ressources concernées et les situations locales. Pour atteindre une gestion locale durable des ressources il faut faire du « sur mesure » local, pas du « prêt à porter » à dupliquer à la chaîne et à « enfiler au chausse-pied ».

J'ai quitté Madagascar et pris ma retraite de chercheur Cirad en mi 2008 mais je continue à y intervenir par des missions de consultance et je me tiens au courant de ce qui s'y passe. J'ai eu encore récemment un exemple supplémentaire de l'incroyable diversité des réalités sociologiques et anthropologiques malgaches. Un collègue a « découvert » récemment un groupe ethnique avec une base matriarcale ce qui est véritablement nouveau et exceptionnel à Madagascar. Une raison de plus d'observer d'abord avant d'agir localement.

À votre avis, comment le recherche menée dans les sciences sociales pourrait-elle être mieux adaptée et utilisée plus efficacement pour servir les politiques en matière de protection de la nature ?

Les sciences sociales ont été et restent encore défavorisées et marginalisées dans tout le secteur environnemental à Madagascar. Combien de sociologues, de juristes, d'économistes ont été recrutées dans le cadre du PAE par rapport à tous les scientifiques relevant des sciences biologiques ? Comment dans ces conditions éviter une dérive inéluctable « d'oubli des populations » et de priorité aux ressources naturelles pour elles-mêmes en oubliant les habitants avec toutes les dérives observées de spoliation des populations résidentes ? Combien de cadres de l'administration forestière sont-ils de formation sociologique ou économique ? Il faut inverser cette tendance qui a démontré tous ses effets pervers.

La protection de la nature socialement équitable est-elle un mythe ? Comment pourrait-elle être réalisée à Madagascar ?

Ce qui est d'abord un mythe à Madagascar (mais pas seulement), c'est celui de la « conservation par les aires protégées » autrement et plus exactement dit de la préservation en excluant les populations locales comme cela a été majoritairement mis en œuvre par les différentes étapes du Programme environnemental malgache avec l'aide des grandes ONG internationales de conservation. L'exemple du *Prunus africana* (*Kotofy*) dont tous les sujets adultes ont été dans les années 90 éradiqués avec arrachage des souches pour extraire des écorces un médicament contre le cancer de la prostate, y compris de l'aire protégée de Zahamena pourtant gérée par

Conservation International préfigurait de façon exemplaire la vidange massive actuelle du bois de rose (*Dalbergia* spp.). Il ne faut pas oublier qu'une moyenne de 10 000 tonnes de bois de rose ont été exportées chaque année depuis les années 1990 à partir de la presqu'île Masoala pourtant Parc national et Patrimoine mondial.

Pour savoir si la protection de la nature socialement équitable peut être un jour à Madagascar autre chose qu'un mythe il faut bien analyser la situation actuelle pour pointer les conditions minimales à réunir et les changements à opérer. La situation actuelle peut être schématisée par la suite logique suivante :

- une demande extérieure solvable et insatiable (Chine, etc.) exerçant une pression constante pour se satisfaire ;
- un État structurellement faible (et de plus en ce moment en crise durable) ;
- une administration forestière squelettique avec des forestiers sous-payés (donc particulièrement sensibles à la corruption comme tous les autres fonctionnaires) ; ces agents forestiers conscients des dangers de l'exploitation illicite n'ont qu'un souci « ne rien voir, ne rien entendre, ne rien signer » pour ne pas se retrouver ensuite un jour entre marteau et enclume dans le rôle du lampiste bouc-émissaire de service ;
- à tous les niveaux de pouvoir des arrivistes pressés de profiter au maximum des opportunités ouvertes par la crise qui deviennent les opérateurs mafieux locaux de la demande extérieure ;
- des paysans spoliés, par la création passée des aires protégées, des espaces et des ressources qui assuraient bon an mal an leur survie misérable et qui voient arriver avec allégresse les opérateurs de l'exploitation clandestine qui leur offrent des revenus et d'une certaine manière « la reconquête », même temporaire et incertaine, de leurs espaces naturels perdus ;
- la création des aires protégées délimitées sur la base quasi-exclusive de la richesse des ressources et de la biodiversité constitue pour les opérateurs clandestins une « quasi-prospection » délimitant les zones intéressantes à piller. Concernant les paysans résidant dans les aires protégées, il ne faut pas oublier cette citation d'Abel Parrot (1935) qui écrivait : « Pour qui connaît la manière évasive et elliptique de s'exprimer des malgaches, cela voulait dire : les forêts étant devenues propriété du *fanjakana*, nous n'avons pas à nous occuper de ce qui n'est plus à nous. ... Je pense donc que, dans certains cas, il aurait été bon de tenir compte des droits réels ou supposés des Malgaches sur les rares forêts du centre de l'île. Dans les deux cas que je viens de citer, les villageois tenaient à 'leur forêt', ils en tiraient des ressources appréciables, ils les protégeaient contre les feux de brousse. » Déposséder les populations résidentes et vous enclenchez le cycle de la dégradation forestière.

Mais l'exploitation forestière légale sur la base des contrats d'exploitation attribués par adjudication (ce qui ne garantit pas à l'État des prix rémunérateurs ni l'absence d'ententes entre les adjudicataires) ne conduit pas non plus à une gestion durable des espaces forestiers et à l'absence de déforestation. En effet supposons un exploitant forestier exemplaire (qui exploite selon des méthodes à faible impact en respectant scrupuleusement le cahier des charges. Un tel exemple n'existe pas à ma connaissance à Madagascar où les « exploitants forestiers » sont plutôt des acheteurs de bois en bord de piste à des bûcherons analphabètes (donc incapables de lire un plan et de respecter des limites n'existant que sur une carte). Donc cet exploitant forestier exemplaire achève l'exploitation de son permis. Il redonne la gestion et la surveillance de cet espace à l'administration forestière. Celle-ci devra assurer la surveillance continue du permis et veiller à ce qu'aucun paysan ne profite du réseau de pistes pour entrer en forêt et défricher par le *tavy* une parcelle de terrain puis une autre. On voit donc que le système d'exploitation forestière légal mis en place depuis 1997 ne garantit absolument pas la pérennité de la forêt.

On voit ainsi que la gestion durable et la fin de la déforestation à Madagascar passent d'abord par un renforcement considérable de l'État Malgache (ce que seuls les Malgaches peuvent faire, cela prendra du temps), par les progrès de l'état de droit (il y a encore beaucoup à faire y compris du côté des bailleurs et des agences de développement ou ONG de conservation dont certaines s'estiment – en contradiction avec leurs discours extérieurs sur l'état de droit – légitimes à ne pas respecter la réglementation malgache et à imposer leurs propres règles *sui generis*). Cela passe aussi par un renforcement de l'administration forestière (que les bailleurs peuvent appuyer). Lors des études provinciales préliminaires à l'élaboration de la loi GELOSE, les populations avaient demandé une plus grande intervention de l'État. La création des communes puis le début des guichets fonciers communaux ont un petit peu répondu à cette attente, mais de façon encore très insuffisante.

La gestion durable des ressources renouvelables et la sauvegarde des forêts contre la déforestation ne pourront être un objectif crédible sans une remise à plat de la politique forestière malgache dans ses objectifs et ses instruments. Ce n'est pas au niveau de quelques pourcentages du territoire que se gagnera ou se perdra la bataille de la sauvegarde de la biodiversité et des forêts malgache mais au niveau de la dizaine de milliers de communes sur l'ensemble du territoire. Avec l'échec de la création des aires protégées et de l'exclusion des populations spoliées de leurs espaces ancestraux il semble bien que la gestion communautaire locale (application de la loi GELOSE) soit la dernière chance de la conservation de la biodiversité et de la sauvegarde de la forêt. Si l'on peut admettre qu'environ 0,5 à moins de 1% du territoire soient mis en défens (en préservation), il faut que le reste des espaces soient mis en gestion conservatoire durable par des contrats GELOSE. Le projet Fonds Français pour l'Environnement Mondial a montré qu'il est possible de valoriser la biodiversité au niveau des communautés de base tout en conservant en zone protégée environ 25% de la superficie totale des zones forestières concernées. Les contrats GELOSE doivent organiser systématiquement une valorisation des ressources exploitées au profit des communautés de base. Les contrats GELOSE dits 'de conservation' qui organisent l'exclusion et la dépossession des populations sont des « marchés de dupes » vis-à-vis des populations et ne durent que le temps de la présence effective de l'opérateur. Les exemples des actions de conservation et de valorisation durable de la biodiversité à Didy montrent que les succès sont possibles à condition de consentir un accompagnement et un appui de durée suffisante. Mais n'oublions pas que

le Programme environnemental n'a consacré à la gestion locale que seulement 4 % des quelques 300 à 400 millions de dollars qui y ont été engloutis !

Si l'on veut mettre en place une exploitation forestière durable à travers des contrats GELOSE qui ne soit pas systématiquement contournée ou concurrencée par une exploitation forestière clandestine à grande échelle il faut remplir plusieurs conditions. D'une part, il faut impérativement organiser pour le bois d'œuvre à l'image de ce qui a été fait de façon exemplaire pour le charbon de bois dans le Boeny (voir l'ouvrage Arina) un système efficace de contrôle forestier décentralisé qui associe des agents forestiers de l'administration, des agents « forestiers » communaux et / ou intercommunaux et les communautés de base impliquées dans l'exploitation forestière durable du bois d'œuvre. Ce système ne pourra fonctionner que sur la base de prélèvements coordonnés de redevances forestières et de ristournes communales qui assurent la pérennité du financement du système de contrôle et la rémunération des agents qui y seront affectés. Comme cela a été fait à Didy, ce système de contrôle peut utiliser un système de marquage des bois marqués en coupe, exploités et commercialisés qui se retrouve jusqu'au marché au bois d'Andravoahangy à Antananarivo. D'autre part, il faut repenser et restructurer la chaîne technique de l'exploitation forestière du bois d'œuvre pour l'adapter à la gestion et à l'exploitation du bois d'œuvre par les communautés de base dans le cadre de contrats GELOSE. Dans ce cadre, les bûcherons des communautés de base ne pourront (comme cela a été fait à Didy dans la forêt d'Ambohilero) exploiter tous les ans ou tous les deux ans dans leur parcelle de forêt communautaire que quelques arbres correspondant à la « possibilité forestière » (c'est-à-dire l'augmentation naturelle du volume sur pied pendant cette période avec évidemment un coefficient de sécurité). Dans les massifs forestiers importants (comme par exemple la forêt d'Ambohilero) cela suppose qu'il y ait un nombre suffisant de contrats GELOSE et que progressivement se mette en place par des travaux communautaires un réseau de pistes permanentes en forêt pour permettre le débardage des quelques arbres exploités chaque année.

Comment pensez-vous que les points de vue divergents sur l'éthique, les concepts et les impacts de la protection de la nature à Madagascar peuvent être conciliées ? Qui doit faire quoi ?

La concertation bien sûr. Mais encore faut-il que tout le monde joue le jeu correctement. Il faut que certains acteurs (certaines ONG internationales) cessent de faire du lobbying uniquement aux niveaux les plus hauts de l'État pour obtenir des décisions autoritaires comme par exemple le choix des objectifs globaux de la vision de Durban. Les choix doivent résulter d'un processus démocratique organisé de concertation ascendant de la base des communautés vers les communes puis jusqu'au sommet de l'État. À cet égard dans les années 1995 à 1997, le processus d'élaboration de la politique forestière avait été réalisé de façon exemplaire avec l'appui de la coopération suisse.

NADIA RABESAHALA HORNING, Middlebury College, USA

Can you start by telling us something about your experience and research/work in Madagascar, and how you perceive the role of social science in conservation on the island?

I started working on conservation/development issues in 1989 as part of a Masters' degree I was pursuing in the United States. My discipline was international transactions, with a focus on political science. On that research trip I visited the UNESCO Mananara Biosphere Reserve and Andohahela National Park (WWF managed). The next trip took place in 1991-92 when I worked in Andasibe for an international development consulting firm. The task was to train Malagasy researchers in rapid appraisal (RRA) methods. Then, in 1993-94, I led a team of Malagasy researchers for a 15-month long USAID-funded study on local capacities for resource management (my team focused on local governance). We went to Montagne d'Ambre (north), Zahamena (east) and Andohahela (south/southeast). This research contributed to the passing of the GELOSE law (96-025). Finally, in 1998-99, I spent 12 months in the South (Toliara region) conducting research for my doctorate on farmers' compliance with rules regulating access to and conservation of forest resources. I studied five communities adjacent to Zombitse, Vohibasia, Analavelona and Ihera forests.

During those 10 years of frequent interactions with Madagascar's conservation community, it became clear that the forces behind conservation (research and projects) were dominated by the western, English-speaking scientific community largely organized and funded by western donor agencies. The 'social sciences', for their part, were represented by anthropologists and 'socio-economists'. Unlike in the natural sciences, social scientists were both Malagasy and foreign, some of whom interacted on a regular basis. This collaboration between nationals and foreigners was not so evident in the natural sciences. Since the end of the 1990s, the number of social scientists coming from Europe and the United States seems to have proliferated, while the Malagasy social science community has shrunk.

In summary, aid and western science have driven conservation efforts in the Island. By comparison, social scientific knowledge has played a lesser, at best supportive, role (to the 'conservation cause').

In your opinion how could the social science research carried out in Madagascar be better adapted to, and used more effectively for, informing conservation policies?

There is plenty of 'local knowledge' in Madagascar, be it in the major cities' universities, research centers, government institutions, or the village communities. Opportunities to tap into this knowledge have been missed due to the (1) failure to recognize or trust this knowledge – largely generated and reported in French and Malagasy; (2) difficulty of obtaining this knowledge, which sometimes requires months or years of painstaking field research with communities that do not think 'like us'; (3) absorption of Malagasy brains and talents into *vazaha* projects, foreign-funded institutions such as ANGAP (*Association Nationale pour la Gestion des Aires Protégées [mcd; now known as Madagascar National Parks]), ONE (Office Nationale pour l'Environnement)*, etc., national consulting firms where the opportunities for material grati-

fication were greater than elsewhere; and (4) indifference or authoritarian tendencies of leaders in charge. It is important to acknowledge this before considering ways to better adapt and use social science research to inform conservation policies.

I think that the first social science project worth encouraging should ask: Who owns conservation policies in Madagascar? This matters a great deal because a government that does not come up with its own policies in a sovereign manner (i.e., according to local understandings of a country's priorities), will likely feign compliance with outsiders' norms and objectives simply to please or appease those whose interests drive national policies because they have the financial means to do so. Environmental conservation, as conceived and practiced in Madagascar since the mid-1980s, is largely a foreign concept, one that purports to serve the long-term development interests of the Island but inadvertently (or deliberately) hurts them by weakening local capacities in the realm of policy making.

Is socially equitable conservation a myth? How could it be achieved in Madagascar?

Socially equitable conservation is an ideal. While it's true that ideals can turn into ways of life where and when the right policies are in place, the concept is riddled with challenges in the African context. What is social equity in the Malagasy context? Most scholars and practitioners think of it as the process of including rural communities in conservation (whatever form this inclusion might take) so that these communities can 'benefit' from conservation initiatives. There is a fundamental flaw here: in the post-independence period, politics has rarely been about the struggle to achieve the general good. Rather, it has been about elites using political office to advance their interests and, by necessity, the interests of foreigners whose visions of development abound. This has happened mostly at the expense of the majority of the Malagasy. Normal democratic systems tie leaders to their constituents through a social contract. In situations where this does not happen, the notion of social equity and the common good can only be alien, if not threatening, to politicians. Moreover, the fact that conservation has not emerged in an organic or democratic fashion, and is controlled by elites and foreigners, makes socially equitable conservation doubly alien to most Malagasy. This includes Madagascar's decision makers. Consequently, achieving socially equitable conservation is likely to be extraordinarily difficult.

How do you think the contrasting views on the ethics, concepts and impacts of conservation in Madagascar can be reconciled? Who should be doing what?

Conservation or conservation discourse? The Malagasy must own the process of sustainable development. As it is, decision makers lack the incentive to think for themselves, to care about the people who depend on sound conservation and development policies for their livelihoods, and to make productive use of both foreign assistance and local knowledge.

SANDRA J. T. M. EVERS, University Amsterdam, The Netherlands

Can you start by telling us something about your experience and research/work in Madagascar, and how you perceive the role of social science in conservation on the island?

Since 1989, I have been working on Madagascar, principally in the Southern Highlands. During fieldwork in 1996, I met a representative of an international conservation NGO in Ambalavao. Upon learning that I was an anthropologist, he responded: "We do not need anthropologists as we have excellent relations with the local population. We have solid contracts with the local kings" Some weeks later, a large part of endemic rain forest in the region was burned down by the villagers as a sign of protest against the activities of the conservation NGO. This was followed by a proposal coming from the NGO for me to work for them as a consultant, as relations with local groups were proving more difficult than first estimated. Later that year I did work with the villagers to find out how they perceived their environment and the conservationist interventions. I discovered that the area which according to the conservationist NGO was inhabited by Bara, was in fact a patchwork of people coming from areas throughout the South. They had a wide range of views, priorities and different tenure relations with the land compared to the few Bara families in the region. They surely did not feel represented by the local 'king'. When I tried to communicate the realities of local social configurations to the NGO staff directing projects in the South, the Malagasy local director said: "And you call yourself a social scientist? Everybody here in Madagascar knows that there are 18 ethnic groups in the island. And the region where you just were, is Bara territory. People are Bara there." He called out for his secretary: "Get me the encyclopaedia". And sure enough, the Madagascar article stated: "18 ethnic groups". At that point my views were clearly held in disregard.

This anecdote highlights the very different perspectives of social scientists and conservation workers in Madagascar. Simply put, social scientists work with the local populations and usually feel very committed to them. Conservationists try to safeguard biodiversity for humankind and in pursuing this goal allot it priority over the interests of local groups, who more often than not are viewed as the principle degraders of the environment. Despite the very different philosophical and epistemological points of departure, I remain strongly committed to seeking dialogue with conservationists, as I believe that in the long term our aims and ambitions might be more compatible than they might appear at first glance.

In your opinion how could the social science research carried out in Madagascar be better adapted to, and used more effectively for, informing conservation policies?

When villagers communicate their discontent by burning down their own environment, clearly nobody benefits. It is a desperate, last resort act. It can be prevented by acknowledging that people living in a specific environment have substantive rights over the fate of their own communities. This means that when conservation activities are contemplated, from their very inception, social scientists could be usefully engaged to work with local groups and map out their varying interests, opinions and aspirations. From there it is possible to lay the basis for a workable relationship. But this would also entail granting equal decisional power

to local groups which would include their right to oppose and even veto certain conservation measures. In other words, conservation NGO's should be willing to accept true partnerships where local voices and views are of equal value to internationally engendered conservationist agendas. I should stress that during my twenty-year research in Madagascar, I have become deeply impressed by how knowledgeable Malagasy are about their environment. They healed wounds that I had, with better medicinal plants than any medication I could import from the world where I came from. They taught me how to navigate the environment with respect, and how to use the fruits of what nature has to offer with moderation and reflection. The idea that is still so prevalent that Malagasy would burn their environment without hesitation to facilitate their cultivation activities is misleading and does not correspond to my own experience. However, political instability and devastating hunger realities, might act negatively upon certain people as well. True appreciation of these challenges that Malagasy face on a daily basis should be part and parcel of social assessments in any conservation targeted area. In short, I hope that we can all agree at some point, that Malagasy have rights as people whose livelihoods and identities are engrained in the land. They have the right to be there and their views are of equal value to visions behind internationally set conservation agendas.

Is socially equitable conservation a myth? How could it be achieved in Madagascar?

If I were to state that socially equitable conservation is a myth, I would preclude the possibility of exchange, dialogue and the creation of points of convergence between social scientists and conservationists. That would be a missed opportunity. After all these years working with Malagasy and analysing the conservation activities in the island, I am no longer so naïve as to think that this can be easily achieved. It demands a true willingness of all parties to consider the point of view of a person coming from a different perspective than your own. I have learned a great deal about how passionate conservationists are and respect their knowledge and commitment. That helps me to assess their points of view rather than to see them as the 'enemy'. I have also been enriched by the years of apprenticeship from the Malagasy about how valuable and crucial their environment is to them. Could it not be so that in the end we all wish for the Malagasy to live meaningful lives in the area where they are rooted while also preserving nature? Reality is however that we are in the luxurious position that we can think of long term futures, while the Malagasy are deprived from this to a large extent as many have daily worries about whether they will be able to find food for their children that day. Precisely by having the awareness that short term and long-term aims are of equal relevance and local voices indeed are just as meaningful as those of other stakeholders, collaboration on a more equal footing should be possible.

How do you think the contrasting views on the ethics, concepts and impacts of conservation in Madagascar can be reconciled? Who should be doing what?

The only way to reconcile contrasting ethical views, concepts and impacts of conservation is through exchange and dialogue. Regularly I notice that both social scientists and scientists working for conservation insufficiently acquaint themselves with other points of view and unfortunately often stereotype the other group. That indeed is a missed opportunity. Maybe we could start by agreeing to disagree on certain points but keep on investing our energies in dialogue at the same time. I remain committed to that, as I believe this brings us better science and a chance to achieve aims of biodiversity and meaningful livelihoods for Malagasy simultaneously.

BRAM TUCKER, University of Georgia, USA

Can you start by telling us something about your experience and research/work in Madagascar, and how you perceive the role of social science in conservation on the island?

I have conducted ethnographic fieldwork in southwestern Madagascar, between Toliara and Morombe, since 1996, in collaboration with the Université de Toliara and CeDRATOM (*Centre de Recherche et Documentation sur l'Art et les Traditions Orales à Madagascar*). Originally we worked with Mikea people, but more recently, with funding from the National Science Foundation (BCS 0650412), we worked with Mikea and their Vezo and Masikoro neighbors. 'Ethnography' means that we live for long periods of time in small communities and participate in daily life. For a total of nine months I lived the small Mikea camp of Belo in the dense, dry, decidious Mikea Forest, in what is now the Mikea Forest Protected Area.

It is incredible to me that even just a few miles from the Mikea forest, few people know anything factual about Mikea. In Toliara I have met people who think Mikea have no language. I have heard repeatedly that Mikea are either Vazimba 'tompontany taloha (mythical original inhabitants of Madagascar), that they are pygmies, that they eat raw food, that they sleep in holes in the ground, etc. This is rubbish. Oral historian Prof. Tsiazonera and I collected oral histories from throughout the Mikea Forest. We found that Mikea trace their ancestry to neighboring Masikoro or Vezo groups, and still belong to Masikoro and Vezo clans. They speak the same dialect of Malagasy as do their neighbors. All Mikea have a very long history of mixing hunting and gathering with agriculture and herding; two centuries ago Mikea were probably primarily herders rather than foragers. Our ethnographic observation reveals that Mikea live pretty much like their Masikoro and Vezo neighbors.

The only Mikea 'pygmy' we ever met was an achondroplastic dwarf who boasted to us that he used to perform in fairs, pretending to be a captured original 'Mikea', speaking an unintelligible language of his invention, and rattling the bars like a wild animal! His performance falsely convinced many people that Mikea are a primitive, pygmy race.

Conservation always affects people. Those places that have natural landscapes and high biodiversity are often inhabited by very poor, very rural people. Mikea are Masikoro and Vezo people who have chosen this lifestyle for the freedoms that it affords. Yet Mikea are consistently, and wrongly, portrayed as unevolved primitives. In order for a conservation project to gain local support, and for it to benefit local people rather than harm them, conservation practitioners must know more than just the local rumors and prejudice about the people their plans will affect.

Here is an example. As Madagascar National Parks (MNP) has planned the Mikea Forest Protected Area and a future Mikea Forest National Park, they have drawn a series of maps of the

region onto which to plot the different zones of protection and usage. Their maps accurately display the villages outside of the forest, but they consistently show the interior of the forest as a blank space with only one or two villages. Our maps, drawn over many years of travel in the forest, show around a hundred communities within the 'blank' space of the forest. Although we have shared our maps with MNP, they continue to map the interior as blank. I assume that they think of the interior as blank. This obviously affected their conservation plans; they have underestimated the population that lives in the forest, and their distribution, due mostly to their assumption that the forest is primarily a 'natural' space.

In your opinion how could the social science research carried out in Madagascar be better adapted to, and used more effectively for, informing conservation policies?

The social scientists and the conservation practitioners tend to disseminate knowledge in different venues for different audiences. When I interact with MNP or WWF, they request copies of my 'reports', but as a professor in a U.S. university I primarily write peer-reviewed journal articles focused on advancing theory of interest to other social scientists. The academically-oriented conservation biologists also tend to write for other biologists. We don't collaborate enough.

Is socially equitable conservation a myth? How could it be achieved in Madagascar?

I really do not know. Participatory conservation is very tricky because of the huge power differential between local people and conservation and development organizations. A fokon'olo (townspeople) cannot really choose to reject a multi-million dollar national park plan backed by the World Bank.

How do you think the contrasting views on the ethics, concepts and impacts of conservation in Madagascar can be reconciled? Who should be doing what?

Honestly, it seems to me that in Madagascar at this time, the conservation practitioners have the power and money. They have to decide they want to listen to social scientists.

GENESE M. SODIKOFF, Rutgers University, USA

Can you start by telling us something about your experience and research/work in Madagascar, and how you perceive the role of social science in conservation on the island?

My experience in Madagascar began in 1994, when I carried out Masters thesis research over ten months in the Andasibe-Mantadia Protected Area Complex during the initial phase of its ICDP (Integrated Conservation and Development Projects). I had come on a grant to work with SAF / FJKM (a partner of the project) on developing low-tech tools for monitoring and evaluating the progress of conservation and development among residents of the villages included in project activities. The methods were informed by Participatory Rural Appraisal, a specialty of Clark University's program in International Development and Social Change, where I was working on a Masters degree. However, I was very interested in social forestry and the theoretical approach of political ecology, so I was concentrating my ethnographic research on the tense relationship between Betsimisaraka peasants, who practice *tavy* there, and the ICDP representatives, many of whom were local Andasibe men. The heads of the project at the time were two North Americans and their Malagasy counterpart, the project's National Director. The lower-tier workers, the local men, often did not see eye to eye with the management. I spend a lot of time in a village adjacent to the Mantadia park, quite remote from the project headquarters at Andasibe, following the advice of SAF / FJKM representative, who was trying to get me out of his hair, assuming I'd be a high-maintenance *vazaha*. (We did become good friends).

I returned for the summer of 1997 and discovered the low-wage workers of the ICDP at Andasibe had organized a strike and formed a union six months earlier due to their dissatisfaction with the project management, and their perception that the terms of their contract were being violated. My Malagasy research assistant and I had befriended many of the workers and conservation agents of the ICDP during that first stint of fieldwork, so they were forthcoming in explaining the events leading up to the strike. These interviews were eye-opening to me because they make me realize that labor was a central though relatively invisible dimension to conservation and development projects. I decided to pursue this theme when I chose to do doctoral studies in anthropology. I returned to Madagascar briefly in 1999 to select a new research site, then in 2000 I began my dissertation research in the Mananara-Nord Biosphere Reserve examining the roles of low-wage, locally hired ICDP workers and their effect on project outcomes. I spent 14 months there.

As for the role of social science in conservation, it has been essential in exposing the causes of conservation failure and in illuminating the assumptions and blind spots of a largely expatriate-driven initiative, where well-intended people with scant knowledge of the political economic history of Madagascar come for the purpose of reorganizing and re-educating rural social life. Even the well-informed get tied up in the expectations and demands of the bureaucracy of conservation: the grant schedules, report-writing, the political spin required to get contract renewals and more funding. The problems are structural, and they endure.

In your opinion how could the social science research carried out in Madagascar be better adapted to, and used more effectively for, informing conservation policies?

The relationship between social science and environmental institutions in Madagascar, in my view, is that the institutional bureaucracy constrains the way social scientific knowledge is delivered and utilized. If you talk to employees at USAID, Conservation International, or the national park service, you see that many of these people are insightful, well-educated, and committed to improving Malagasy people's lives. They have also expressed a lot of frustration with what is demanded of them by higher-ups. I have also found as a researcher that my findings were only useful to projects if they were drawn up in a specific way: as digestible, quantifiable data, as goals, objectives, and results – in short, in a form that makes it easier for institutions to write up reports that illustrate before / after scenarios. This is understandable, but it is also frustrating. Qualitative data that describe how rural people feel about conservation and development interventions due to a history of land alienation and unequal distribution of resources (including ICDP resources) are

not helpful to institutional actors who want to implement clear-cut strategies and get clear-cut outcomes. Even the question posed above demands this kind of answer, implicitly.

Is socially equitable conservation a myth? How could it be achieved in Madagascar?

I don't have an easy answer, but it seems to me that if biodiversity conservation is truly the goal, and the situation is truly as dire as we think, if this is really a matter of species survival on a planetary scale, than I think why not try a large-scale 'conservation corps' program where rural people are paid wages directly to terrace and fertilize the farmlands, establish tree nurseries, reforest *savoka* [*mcd*; secondary scrub fromations], and so on?

How do you think the contrasting views on the ethics, concepts and impacts of conservation in Madagascar can be reconciled? Who should be doing what?

I think that for those of us who know rural Madagascar as outsiders, whether Malagasy or expatriate, we need to take an honest look at the conditions of our life and the lives of the majority of Malagasy people, who are scraping by the best they can. Education matters, of course, as do economic options. But the rate of species and habitat loss in Madagascar, particularly now with the new wave of extractive activity in the national parks, far out-paces what any kind of conciliatory discussion would achieve. I say, amass all intellectual and budgetary resources and try something radically new.

JEFFREY C. KAUFMANN, University of Southern Mississippi, USA

Can you start by telling us something about your experience and research/work in Madagascar, and how you perceive the role of social science in conservation on the island?

In my experience social science, and especially cultural anthropology, are well positioned to participate in conservation efforts in Madagascar. But first of all the 'conservation efforts' need not to be foreign to the people who will have to live with conservation as it impacts their daily lives. Input is needed from the people themselves who have an intrinsic stake in conservation. We can find out the reasons why, for example, Betsimisaraka hill farmers decide to or decide not to harvest illegal rare hardwoods from Masoala, *vis-à-vis* enormous short-term economic benefits and even larger long-term detriments.

There will always be opportunists. But in my experience, most Malagasy dislike the changes they have experienced in their local habitats. They would prefer to see more options open to them, more sustainable ways of living with nature in a harsh economic climate, rather than a few paths to environmental devastation.

In your opinion how could the social science research carried out in Madagascar be better adapted to, and used more effectively for, informing conservation policies?

I advocate collaborative research involving people with numerous experiences and ideologies. Conservation is too complex to be homogenized into a 'one size fits all' mentality. Getting people with diverse backgrounds and areas of expertise to work together in conservation, attempts to at least contextualize the complexity inherent in conservation. The greatest error made by the conservation sector in Madagascar, in my opinion, was to see the problem as one-dimensional; that the blame fell solely on 'uneducated' Malagasy peasants who with a little tutoring and arm twisting would miraculously 'recognize' their mistakes and jump onto the conservation bandwagon.

My work with Jonah Ratsimbazafy has convinced me that by integrating local people into the research design, rather than as *ad hoc* harbingers of 'the need to conserve', bring complexity into the forefront, which they can inform conservation policies. We must stop thinking of policies as quick solutions and get down to the real work of making local solutions work for local communities.

Is socially equitable conservation a myth? How could it be achieved in Madagascar?

There is little equality in today's world. What makes us think that conservation is any different from any other institution? Conservation is about sacrifice – not by those working in the sector for a living and a very good living in many cases – by people affected by it in their day-to-day lives. The sacrifice can be made palatable to Malagasy people – who, by the way, know something about sacrifice, since it is woven throughout their culture – by giving them, the primary stakeholders in conservation, various rights and benefits.

For ways to achieve more socially equitable conservation in Madagascar, I suggest readers take a look at Dr. Ratsimbazafy's work in village conservation. He and some colleagues published a nice chapter that served as the 'last word' to the edited volume *Greening the Great Red Island* [Africa Institute of South Africa, 2008].

How do you think the contrasting views on the ethics, concepts and impacts of conservation in Madagascar can be reconciled? Who should be doing what?

The contrasting views on the ethics, concepts and impacts of conservation in Madagascar need a collaborative methodology to pull out each area of complexity. Frankly, I would prefer to have a philosopher of ethics work on bringing out the ethical issues. Ethnographers are good at sussing out the impacts of conservation on local communities. And theoretically focused anthropologists are well suited for identifying concepts and their meanings in culturally relative contexts.

Of course, there is plenty of work for environmental scientists, natural historians, geographers, and development specialists too. But the first thing to do is involve local people into the planning and implementation of conservation efforts. They must be recognized as our teachers.

Travelling through time - Voyage dans le temps

In this rubric the journal invites people to speak about those having left their mark in Conservation & Development in Madagascar. Here we call on Margaretta Jolly to tell us about:

ALISON JOLLY AND HANTANIRINA RASAMIMANANA: THE STORY OF A FRIENDSHIP

Hanta says to me, 'Your mother has her head in the clouds'.
My mother says to me, 'Hanta has a lot of pots on the boil'.
Hanta and my mother both say, 'We can't stop to chat, we're working on our conference paper.' And they disappear into the study and don't come out till tea time. After that, they disappear to Berenty for a month.

My mother, Alison Jolly, is a primatologist at the University of Sussex in England. For as long as I can remember she has been studying lemurs. She has a story about how it began. Back in 1960 she was a student at Yale, beginning a doctorate on sea sponges. A professor arrived with lemurs sent from the Institut Pasteur in Madagascar. The sponges were instantly forgotten. By 1962, she was on her first field trip to Madagascar, a twenty five year old American on what was to be a life changing journey. Soon she was marvelling at close-up views of ring tails bounding through the extraordinary strip of gallery forest at Berenty. *Lemur Behavior*, 1966, was her first interpretation of the animal society she found there. What astonished her and, subsequently, other evolutionary theorists, was that it was matriarchal, with females wholly dominating the males.

This turned into a fascination with lemurs, Berenty, and with Madagascar that has now lasted almost 50 years. Her early observation of female dominance fuelled further publications and debates, interestingly chiming with a period in which the women's liberation movement supported new perspectives on old human-male dominated orthodoxies. My mother meanwhile sustained her professional work with part time academic positions and four noisy children who (at least in my case) didn't always appreciate her frequent disappearances to what felt like a very distant country. Then again, from our childhood trips with her, flavoured with vanilla and roasted peanuts, I can see why she couldn't let it go.

Her complex attachment to Madagascar is evident from her 1975 *A World Like Our Own: Man and Nature in Madagascar*. This book situates the puzzle of lemur behaviour in the context of Malagasy environment and history. From my point of view, I no longer felt that Mum was a conservative sociobiologist (the subject of hot-headed arguments in my twenties, as I discovered Marxism!). Instead she was ahead of the game, putting biology into society as much as the other way round. Simply expressed, it began to seem obvious that working with lemurs was about conservation and working with Malagasy visionaries, and, more profoundly, that humans and animals' futures depend each other. My mother's work developed as she started listening and watching in new ways. Her latest book interweaves oral histories of Tandroy locals, French/Malagasy land owners and politicians, and American conservationists with the imagined voices of lemurs, all living and struggling together. *Lords and Lemurs: Mad Scientists and Kings with Spears* speaks of the tragedies as well as comedies of this struggle, in the face of appalling political and economic challenges to Madagascar, but also the eccentric, vivid reality of inter-dependence. She has become involved in discussions about development and the politics of conservation: Berenty Reserve has survived but nothing can be taken for granted. My mother, a natural optimist, has had to bring her head out of the clouds.

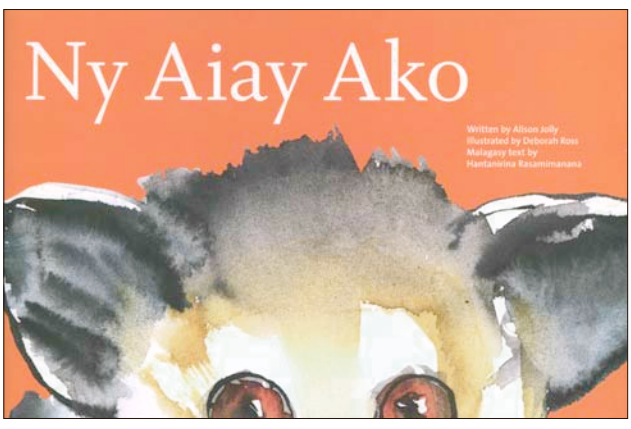
Hantanirina Rasamimanana has unquestionably been a guide on this road. Hanta first met my mother in 1983. Born and raised in Antananarivo, she is 17 years younger than Alison, and fizzes with an ironic kind of energy. Originally trained in animal

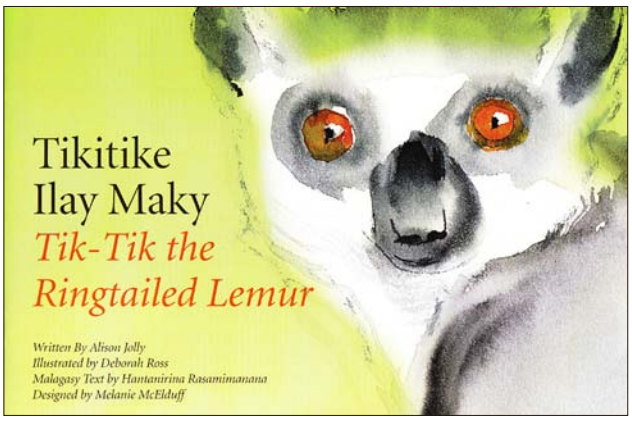
Hantanirina Rasamimanana (left) and Alison Jolly (right).
©RATOVONIRINA Ando/Fev 2008/Alaotra.

husbandry at the Veterinary Academy of Moscow, she was part of the generation who were sponsored to study in Russia under Ratsiraka's socialism, and she returned to teach at the École Normale Supérieure. Soon juggling her own family life, Hanta also turned to studying ringtails, publishing on issues as varied as feeding behaviour, energy expenditure and the still unsolved question of why the females are dominant. Recently she had the honour of being dubbed 'Madagascar's Lemur Lady' by the television channel CNN, a typically silly American way of putting it, but one indication of her prominence now as a scientist and spokesperson. Perhaps more important is her Knighthood of Malagasy National Order, and her ever-increasing responsibilities in Malagasy academia, including a new Master's degree in Primate Conservation run in Mahajanga and the Comoros.

How lucky Hanta's students are! For she gives every last drop. I remember her explaining why her students were always round her house at midnight: they were gaining precious access to a computer. For Hanta, the complexity of life and ecology in Madagascar is obviously personal. She has also had to combine research with teaching and the sharp end of global politics. I remember her welcoming house in Tana, and her children's dry humour in the years they have lived with us. But sharing computers is not easy, and I also remember the Kafkaesque difficulties of getting the simplest visa to attend a primatology conference in England. My mother has very often been at the other end of the phone in such situations.

Hanta and my mother have helped each other through the years. Insider and outsider, both of them, they keep a friendship across the inequalities of life in England, America and Madagascar. They share as mothers as well as colleagues who have been there for the long haul and indeed, including some of the worst things that can happen to a mother. As a daughter, what is most important and inspirational to me is how they have together nurtured a new generation of Malagasy primatologists and conservationists, through other people's children, if not their own: the masters and doctoral students who are the future of conservation in Madagascar. Above all, the Ako Project, now widely supported by UNICEF, shares the wonders of Malagasy wildlife with young children through storybooks and posters on six of the hundred-odd species of lemurs. Mum is the English author, Hanta the Malagasy author, and the magic watercolors are made by their friend Deborah Ross. I can say that my mother has been more honoured by the excitement of one five year old girl in Taolagnaro making lemur 'whoop!' noises than she was getting her Life Time Achievement Award at the International Primatological Association conference in Japan this year.





The Ako Project, now widely supported by UNICEF, shares the wonders of Malagasy wildlife with young children through storybooks.

I will end with a snippet of a letter from my mother to Hanta from Panama, where she was visiting a reserve, because I think it speaks for itself!

"What I have learned about primatology, Hanta: it has gone HI-TECH. One MUST have DNA analysis of male paternity. This can be done from feces, not just blood. One MUST have GPSs and ArcView range maps. One MAY have data loggers and radio-tags, but these aren't absolutely necessary.

But the most interesting thing for you is Ketone Strips. These are available over the counter in US drugstores, used by dieters. If you are actually burning fat, your urine turns the little paper strips purple. So you can figure out if a primate is nutrition-deficient by just running under it when it pees on a leaf, and seeing if the paper strip turns purple. A student can follow this through the seasons.

When I think of all the times I have moved out of the way of peeing and pooping primates, instead of running underneath to catch the stuff--what a waste!"

Hanta, busy with the new MSc in Primate Conservation, just wrote back,

"HELLO Alison
I am in a town where internet is very hectic, Mahajanga, and the rooms contain a lot of mosquitos; but I see you are having a good time!"

Margaretta Jolly, November 2010

IMPRESSUM

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COVER PICTURE: Dominique Halleux: Madagascar in the eyes of a girl from Vohipeno. *Madagascar dans les yeux d'une jeune fille de Vohipeno.*

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