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

IN THIS ISSUE

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Institute and Museum of Anthropology
University of Zurich
Winterthurerstrasse 190
CH-8057 Zurich
Switzerland

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Appréhender le changement climatique dans une interface Homme-forêt

La sauvegarde des forêts tropicales est une problématique déjà relativement ancienne qui est en train d'être supplantée par la question du changement climatique et ses impacts forestiers. Plus précisément, à l'heure actuelle, presque toutes les actions de grande portée en faveur des forêts tropicales sont présentées dans un contexte de changement climatique. Effet de mode, moyen de réorienter les flux financiers ou opportunité de relancer la question des forêts ? On préférera y voir une opportunité bienvenue de donner, grâce à la foresterie du carbone, un nouveau souffle à la réflexion sur l'aménagement et la gestion des forêts tropicales.

Peut-être est-il utile d'expliquer ce que l'on peut qualifier de nouveau souffle. Durant quelques dizaines d'années, à savoir la période 1950–1980, les relations Nord-Sud en matière de coopération au développement et de recherche scientifique dans le domaine forestier ont été marquées essentiellement par les apports techniques, le reboisement sous toutes ses formes servant de guide. La période qui a succédé est caractérisée par l'émergence de mots-clés comme la participation, la biodiversité, le développement équilibré homme-femme, l'autonomisation (empowerment), la gouvernance, et maintenant – nous en sommes les contemporains – le changement climatique. Ces mots-clés illustrent des infléchissements, voire des changements au niveau des politiques de développement. Les résultats obtenus sont-ils à la hauteur ? Le doute est permis … Quelques exemples : (i) après 50 à 60 ans de relations forestières Nord-Sud postcoloniales, il est difficile d'évoquer des progrès significatifs en matière de gestion durable des forêts tropicales ; la part « illégale » de l'exploitation des bois tropicaux ne diminue pas ; (ii) des dizaines d'années d'efforts en faveur de la participation et souvent contre l'autorité de l'Etat (les deux approches étant souvent non seulement concomitantes, mais liées) n'ont pas mené à des améliorations concrètes et à grande échelle en ce qui concerne la dévolution de droits d'usage aux populations locales ; (iii) la destruction et la dégradation des forêts tropicales ralentissent à peine ; il suffit pour s'en convaincre d'étudier les publications quinquennales de la FAO sur l'état des forêts dans le monde ; (iv) dans le même registre, il serait intéressant d'examiner si la situation de pauvreté des populations péri-forestières s'est améliorée, depuis toutes ces d'années !

Pourtant, nombre d'exemples concrets et, surtout, les résultats de la recherche scientifique montrent régulièrement et de manière probante, que la réflexion sur l'avenir des forêts ne peut être dissociée de l'intérêt des populations locales. À l'heure de l'omniprésence du changement climatique dans la discussion, menée de manière de plus en plus critique (Caramel 2013), le moment est venu de relancer, de revaloriser et, sans doute, de réimaginer la participation des populations à l'aménagement et à la gestion des forêts tropicales.

Le propos de cet éditorial tire largement parti de plusieurs recherches entreprises ces dernières années à Madagascar sur les questions d'aménagement et de gestion des forêts plaçant, dans toute la mesure du possible, l'Homme au centre de la démarche de recherche afin d'en dégager les éléments constitutifs d'une interface Homme-forêt mieux comprise. Ces programmes ont été réalisés conjointement par le Département Eaux et Forêts de l'École Supérieure des Sciences Agronomiques (ESSA) et l'École Polytechnique Fédérale de Zurich.

Chaque recherche apporte son lot de résultats, d'observations de toute nature et de recommandations. Les résultats de ces travaux sont souvent inédits ; parfois, ils confirment un savoir préexistant. Il sera question ici principalement de questions socio-économiques et socio-politiques.

L'idée d'un programme de recherche sur les fragments forestiers à Madagascar (Urech 2011, Rabenilalana 2011) repose sur le constat qu'une part importante des massifs forestiers ont été détruits ou morcelés, créant des fragments de forêts plus ou moins interconnectés, qui dessinent une mosaïque paysagère. Les fragments de forêts servent (i) de ressource de produits et de services essentiels pour couvrir les besoins des populations locales et (ii) de tremplin pour la préservation de la biodiversité, notamment par une fonction de relais du réseau des massifs encore préservés.

Dans ce contexte, un fragment correspond à toute surface de forêt naturelle d'une superficie inférieure à 500 ha et entourée de terres agricoles ou de jachères, donc non connectée à un massif forestier. Plus encore que les massifs, les fragments ne bénéficient pas d'une protection qui les préserverait d'une disparition complète, sachant que la cause principale de défrichement des forêts réside dans la culture sur brûlis.

Une recherche portant sur le stock de carbone en forêt dense a été menée parallèlement aux travaux précédents, avec des objectifs différents (Rakoto Ratsimba 2011), elle constitue une contribution importante à la définition d'une foresterie du carbone par l'usage de la télédétection en forêt dense humide, dans un contexte de déforestation et de dégradation des ressources forestières. L'auteur relève que dans le cadre de la mise en place d'un système de mesure, rapportage et vérification du carbone (MRV) à l'échelle d'un pays, des études au niveau local demeurent indispensables pour l'observation des niveaux de dégradation. Se focalisant sur la réduction des émissions de carbone, il souligne que la réussite des programmes REDD est étroitement liée avec la question de la propriété du carbone mais également avec l'intégration de la communauté locale dans l'ensemble du processus, notamment en ce qui concerne les droits d'usage ou de propriété.

Dans le Menabe central, de nombreuses recherches ont été menées sur les forêts, les questions sylvicoles notamment, l'exploitation et la transformation du bois ou même l'agroforesterie (Ganzhorn et Sorg 1996), mais peu nombreuses sont celles qui se

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consacrent à des sujets interdisciplinaires à une échelle régionale.

Deux thèses ont été réalisées parallèlement et en étroite concertation. La première par Dirac Ramohavelo (2009) a considéré les ressources du paysage forestier en s'efforçant de dégager les points de vue des habitants des villages dans lesquels les recherches ont été menées ainsi que le rôle des ressources forestières dans les stratégies paysannes. Dans la seconde (Andriambelo 2011), le même paysage a été étudié, mais de manière plus forestière. Le chercheur s'est situé à l'intérieur du massif et a porté son regard vers l'extérieur, partant du constat que dans le but de trouver un équilibre entre la conservation et les pratiques locales, la notion de gestion des ressources forestières a évolué sous l'influence de termes comme participation, décentralisation, droit d'accès et droit de propriété. Sa recherche est basée sur les besoins (domestiques et commerciaux) des paysans par rapport aux ressources ligneuses des forêts qui les entourent ou qu'ils gèrent.

Contrairement aux recherches effectuées dans la zone des forêts pluviales, les travaux concernant le Menabe central ne considéraient généralement les forêts secondaires que de manière marginale. D'où un autre travail de recherche (Razafintsalama 2011), basé sur le constat que si les forêts secondaires du Menabe renferment des biens que la population utilise pour satisfaire ses besoins en produits forestiers, celle-ci accorde plus de valeur d'usage aux forêts secondaires qu'aux forêts intactes. Ainsi, le prélèvement atténue la pression exercée sur les forêts naturelles intactes, concrètement, les stratégies villageoises ont un impact moins important lors de prélèvements des ressources forestières (culture sur brûlis, pâturage, collecte de produits).

Cette analyse des recommandations formulées et des observations reproduites dans plusieurs thèses de doctorat réalisées ces dernières années à Madagascar permet de tirer les conclusions suivantes : (i) L'interface Homme-forêt s'inscrit dans une relation souvent complexe, beaucoup plus complexe qu'il n'apparaît au premier abord, entre les communautés humaines et les ressources naturelles renouvelables. (ii) L'action de l'Homme est souvent guidée par des impératifs rationnels de gestion, compte tenu des situations écologiques, sociales et économiques données. Les familles paysannes ont une vision intégrée des ressources sur lesquelles elles ont la maîtrise, où une certaine maîtrise. Si les chercheurs mettent régulièrement ce constat en évidence, les responsables des actions de développement et les administrations en tiennent assez peu compte. (iii) En extension du point ci-dessus, il est possible de suggérer, globalement, que les populations péri-forestières agissent de manière souvent plus durable que les autorités gouvernementales, les services administratifs et même les organisations de protection de la nature. Ces populations agissent dans les massifs, dans les fragments ainsi que dans les forêts secondaires. (iv) L'agriculture est non seulement la principale cause directe de la déforestation, mais elle constitue aussi l'un des moyens, peut-être le seul, pouvant entraîner une amélioration significative des conditions de vie des populations locales. (v) Dans la gestion, les forêts (massifs, fragments et forêts secondaires) ne doivent pas être prises en compte séparément, mais considérées comme un élément constitutif du paysage et des moyens d'existence de la population. (vi) À ce jour, les modèles de participation à l'aménagement et à la gestion des ressources forestières n'ont pas amélioré de façon significative l'état des forêts et les conditions de vie de la population. Il est même possible de postuler, comme l'ont suggéré Urech et ses collaborateurs (2015) en appliquant à Madagascar les critères de réussite de la gestion forestière par les communautés locales proposés par Ostrom (1999), que les conditions d'une démarche participative ne sont pas données à l'heure actuelle. (vii) La problématique du changement climatique se superpose depuis plusieurs années à la question de l'aménagement durable des forêts. Des potentialités nouvelles pourraient s'en dégager, mais présupposent que la distribution des revenus ait lieu de manière équitable entre les différents groupes d'acteurs et que notamment les plus faibles (en général les familles paysannes des confins de la forêt) ne soient en rien lésés

Ces conclusions mènent logiquement à proposer une redéfinition des modalités d'aménagement et de gestion des ressources forestières, impliquant l'État, les administrations ainsi que les appuis extérieurs. Les pistes ci-dessous sont suggérées : (i) La participation des populations locales à l'aménagement et à la gestion des ressources naturelles, des paysages, des terroirs constitue un objectif central de la gestion du patrimoine, au sens large de ce terme. Les difficultés que les populations rurales rencontrent en ce qui concerne la productivité agricole, l'accès au marché, l'accès aux connaissances, les droits d'usage et de propriété, la reconnaissance politique, leur système de valeurs doivent être pris en compte dans le cadre de processus participatifs renouvelés, transparents et équitables. (ii) Il convient d'opérer une distinction claire entre aménagement et gestion. L'aménagement est la planification de la mise en valeur de ressources pour répondre à des besoins actuels tout en préservant la capacité de production future. La gestion est la mise en œuvre de l'aménagement par des mesures d'entretien, de récolte, de reconstitution et d'amélioration du potentiel de production. La participation débute avec l'aménagement et ne peut pas se limiter aux modalités de gestion. Qui peut se targuer de n'être jamais intervenu auprès d'une population donnée avec des idées préconçues quant à la manière d'aménager une ressource ? C'est une chose que de disposer de compétences et de moyens liés à ces compétences – c'en est une autre que d'imposer des points de vue. (iii) Un séminaire organisé à l'ESSA en 2008 a mis en évidence qu'en ce qui concerne la gestion contractualisée des forêts, l'une des causes expliquant l'hétérogénéité des approches et les difficultés rencontrées par et avec les populations locales réside dans la diversité des conceptions ou des philosophies véhiculées par les intervenants-facilitateurs et dans leur fréquente incapacité à en faire abstraction. Il en découle une grande difficulté pour les services administratifs à assurer un minimum de coordination, en d'autres termes à garantir la haute surveillance qui leur incombe. Les intervenants-facilitateurs doivent être mieux encadrés par les services administratifs et agir selon des normes d'intervention uniformisées. (iv) La participation « de tous les acteurs », comme il en est de plus en plus souvent fait état, est un leurre. Un statut prioritaire doit être reconnu et appliqué dans les faits aux populations locales, celles qui sont directement concernées par l'aménagement et la gestion de ressources. (v) Il n'est plus possible, aujourd'hui, de faire l'impasse sur l'approche paysage ou écosystémique en intégrant climat, géologie et sols, relief, habitants et formes d'habitat, ressources et modes de mise en valeur dans les questions d'aménagement. La notion de paysage, dans le sens qui lui est donné ici, a beaucoup de similitude avec celle de terroir. Rappelons que le terroir est le lieu de vie et d'activité d'une communauté donnée, en règle générale rurale. Un terroir présente une géométrie variable et des intensités de gestion différentes selon

les ressources considérées. (vi) Un grand ministère regroupant l'agriculture, l'élevage, l'agroforesterie, la foresterie, les ressources de l'eau, la protection de la nature, disposerait de l'autorité nécessaire pour coordonner l'aménagement des ressources naturelles et exercer la haute surveillance. Cette idée, relativement ancienne, est peu appréciée des forestiers, qui craignent d'être phagocytés par l'agriculture. (vii) Exercer une haute surveillance signifie disposer d'un cadre légal et réglementaire et d'en assurer la mise en œuvre. Il faut du personnel formé, des moyens et un appui politique. Les universités peuvent constituer la cheville ouvrière de la démarche. (viii) La foresterie du carbone se superpose à la problématique de la participation au sens large de ce terme et en occulte souvent les difficultés. Le changement climatique et la foresterie du carbone peuvent ouvrir la voie à des approches plus sociales, plus équitables, en un mot plus prometteuses de l'aménagement et de la gestion des ressources naturelles. Dans ce but, l'intérêt des populations locales doit figurer en tête des préoccupations.

Jean-Pierre Sorg
Ex-Groupe de foresterie pour le développement
Swiss Federal Institute of Technology, Zurich
Switzerland

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ARTICLE

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First records of illegal harvesting and trading of black corals (Antipatharia) in Madagascar

Gildas Todinanahary[I]*, Lucas Terrana[II]*, Thierry Lavitra[I], Igor Eeckhaut[II]

Correspondence:
Lucas Terrana
Marine Organisms Biology and Biomimetics, University of Mons, Belgium
E-mail: lucas.terrana@umons.ac.be

ABSTRACT

Black corals (Cnidaria: Antipatharia) have been used all around the world for a long time, whether as money or for medicinal purposes and jewellery manufacturing. Except in Hawaii where these fisheries are well known, black coral harvests are usually made without any control or any management. This is the case in many tropical islands and particularly in Madagascar, where the illegal trade is continually expanding. Since 2011, an illegal traffic of black corals has been occurring in the main cities of the southern and coastal regions of Ambovombe and Tolagnaro. In 2014 and 2015, hundreds of kilograms of black coral skeletons and a lot of diving material were seized by the authorities in the Anosy and Androy regions. Despite this and the continual harvesting of these natural resources, there has been no study of the excessive exploitation in this region. This paper is the first to talk about this new threat and to analyse and discuss the benefits of these fisheries. The first seizures and the efforts carried out on the island to stop the trade are explained. This paper highlights the urgency of studying these corals before making an appropriate conservation and management plan.

RÉSUMÉ

Le corail noir (Cnidaria : Antipatharia) est exploité dans le monde entier depuis très longtemps. Bien qu'inscrit à l'Annexe II de la convention sur le commerce international des espèces menacées d'extinction (CITES), le squelette du corail noir est utilisé sous forme de monnaie d'échange, à des fins médicinales ou pour être transformé en bijoux.Excepté à Hawaii où s'est développé une pêcherie durable, leur collecte s'effectue depuis toujours sans le moindre contrôle ni la moindre gestion. C'est le cas dans de nombreuses îles tropicales, et plus particulièrement à Madagascar où le commerce illégal se développe de plus en plus. Depuis 2011, un trafic se déroule dans les principales villes côtières du sud, Ambovombe et Tolagnaro. En 2014 et 2015, des centaines de kilos de squelettes de coraux noirs et une grande quantité de matériel de plongée furent saisis par les autorités dans les régions d'Anosy et Androy. Malgré cela, et pendant que les ressources naturelles s'épuisent continuellement, il n'existe aucune étude sur le déroulement d'une telle exploitation. Cette étude est la première à analyser et discuter des collectes ayant lieu à Madagascar. Les premières saisies ainsi que les efforts mis en place sur l'île pour stopper les collectes sont expliqués. L'étude met également en exergue l'importance et l'urgence d'accroître les connaissances sur les coraux noirs avant de pouvoir développer un programme de conservation durable de ces ressources.

INTRODUCTION

Antipatharians, called black corals, are marine organisms that have attracted people for a long time. Historically, they were used by religious people and for medicinal purposes (Bruckner et al. 2008). During the Paleolithic, some populations used them as money to trade (Tescione 1968) and from antiquity to the present, they have been used worldwide mainly for jewellery. Small black coral fisheries have always existed all around the world, but it increased with the development of scuba diving equipment and techniques until it became an important source of income in several regions and countries, such as Cayman Islands, Cuba, Mexico, Taiwan, the Philippines and the Dominican Republic (Castorena and Metaca 1979). The latter three were responsible for the trade and export of 72 metric tons and 7,400,000 pieces of black coral between 1982 and 1998. In 1996, 473,000 black coral pieces imported into the United States were reported to be worth $447,000 (Guitart et al. 1997).

At the moment, these fisheries are best known, managed and controlled in the Hawaiian islands. Grigg (1993) explains in detail the precious coral fisheries in the region. The black coral meadows located around them were discovered in 1958 at between 30 and 75 meters depth and 14 species were found within it, with 3 being harvested and exploited: *Antipathes dichotoma*, *A.grandis*, and *Myriopathes ulex*. The others are found at over 100 meters depth and their diameter is not sufficient to be profitable to fishermen (Grigg and Opresko 1977). In 1969, black coral fisheries and precious coral exports to Asia were worth $2 million in Hawaii. Quickly, population and stock management problems appeared and academic studies started in 1970 led to the development of a selective harvesting system utilizing a manned submersible

I Polyaquaculture Research Unit, Institut Halieutique et des Sciences Marines, Université de Toliara, Madagascar
II Marine Organisms Biology and Biomimetics, University of Mons, Belgium
* These authors contributed equally to this work

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(Grigg et al. 1973), allowing the development of the sustainable management of these resources. These selective fisheries and coral management are based on coral growth rates and reproductive cycles, which are supported and approved by the Western Pacific Regional Fisheries Management Council (Grigg 1976). Fishermen also need a license and an authorization to collect black corals around the Hawaiian islands (Bruckner et al. 2008). The Hawaiian islands make $50 million with the precious coral fisheries, with $33 million for black corals (Grigg 2010). These fishery industries employ about 1,000 people: the current wholesale value of unworked black coral being about $US 35 per pound, and the retail prices for manufactured black coral jewellery range from around $US 35 to $300 for earrings to over $US 3,000 for more ornate necklaces and bracelets (Grigg 1993, Kahng and Grigg 2005).

Elsewhere in the world, very little is known about black coral fisheries and management. At this time, the United States is the main importer, followed by Japan, but the USA is importing less than 1,000 pieces per year, which is a very small quantity of corals. The biggest provider of black corals is Taïwan, with more than 90 percent of the total of black coral legally sold, while the most harvested region is the Philippines. There is no official report of black coral trade in Africa nor in Madagascar but it is notorious that the illegal trade occurs without exportation control and management. In Madagascar this illegal trade involves fishermen, small collectors in villages, foreign scuba divers and exporters in big cities where a kilogram of black coral is bought for €50 from fishermen.

The global conservation status of black coral has not been evaluated, but they are protected by international treaties restricting their exploitation and exportation/importation. According to the CITES (Convention on International Trade in Endangered Species of wild fauna and flora), the main threats are harvesting and invasive alien species such as the octocoral *Carijoa riisei* (Kahng and Grigg 2005). Black coral exploitation generally occurs in different steps: seabed exploration, discovery of black coral meadows, exploitation and depletion (Grigg 1989). Their stocks gradually run out, and fishermen continually search for new meadows to maintain sales. Overexploitation of black coral quickly leads to local population extinctions causing a great loss of biodiversity without a proper management plan. Conservation plans for black coral are, however, difficult to establish because these organisms are characterized by a slow growth, a delayed first reproduction (after about 10 years), a long life, an annual release of gametes, a high colony fecundity, a low recruitment of larvae and a slow rate of recovery when individuals are damaged (Parker et al. 1997). Mortality often results from sediment covering and substrate erosion (Grigg 1993). At the moment, there is no integrative biological data on shallow-water black coral populations from the Indian Ocean and it is consequently not possible to properly manage their populations in this region.

BLACK CORALS: UNKNOWN RESOURCES IN MADAGASCAR

Research on coral reefs began in Madagascar in 1961 with the establishment of the first marine station of Toliara. French researchers from the marine station of Endoume in France studied the southwestern region of Madagascar, including the Great Reef of Toliara (GRT) (E043° 20', S23° 30'), and the coral reefs of the Bay of Ranobe (E042° 58', S23° 18'). The first published results describe the location and the physiography of these reefs (Clausade et al. 1971, Thomassin 1971, Battistini et al. 1975). Since this time, several research programs have been carried out on the coral reefs of the region (Pichon 1978, Laroche and Ramananarivo 1995, Salimo 1997, Vasseur 1997, Laroche et al. 1997, Gabrié et al. 2000, Bruggemann et al. 2012, Andréfouët et al. 2013), but none of these included black corals.

No scientific study on black corals has been made in Madagascar until now: their communities remain completely unknown. Moreover, there is no data available from the main fishery and marine science research centres of Madagascar (Fishery and Marine Science Institute - IH.SM and the National Centre for Oceanographic Research - CNRO), or from the National Environmental Research Centre (CNRE). This publication is the first to exclusively talk about antipatharians from Madagascar and the problems related to their illegal exploitation, with the lack of management.

THE FIRST OFFICIAL SEIZURE OF BLACK CORALS. In 2014, a total of 178 kg of illegally-harvested black coral was seized by the Fisheries Control Centre (Centre de Surveillance des Pêches - CSP, based in the capital Antananarivo), in the southern regions of Anosy and Androy (Figures 1 and 2). Samples of the seizure were sent to the authors. The diameter of the base of the samples and their length were recorded with their origin (Table 1). Most of the black coral samples were fragments with a branch diameter higher than 35 mm (Figure 2). The harvested corals seized in Tolagnaro were first branched corals with a bush-like shape before being cut into fragments. Our investigations have confirmed that the bigger the branches are, the more expensive the price is. Furthermore, during the 31st May 2015, a new official seizure of

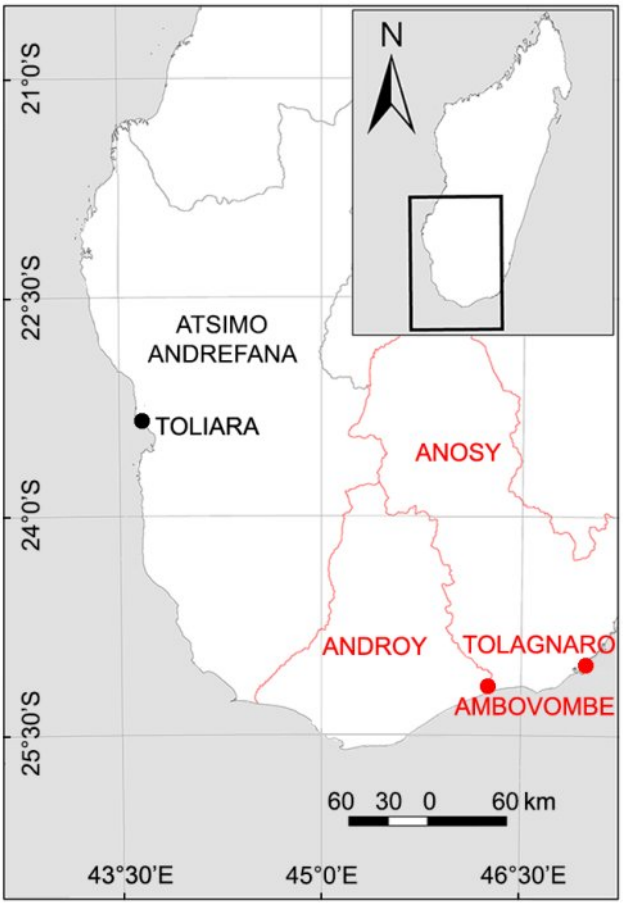

Figure 1. Southern coast of Madagascar. The two main regions concerned by the illegal harvesting of black corals, Androy and Anosy, are highlighted in red. Their capitals are respectively Ambovombe and Tolagnaro.

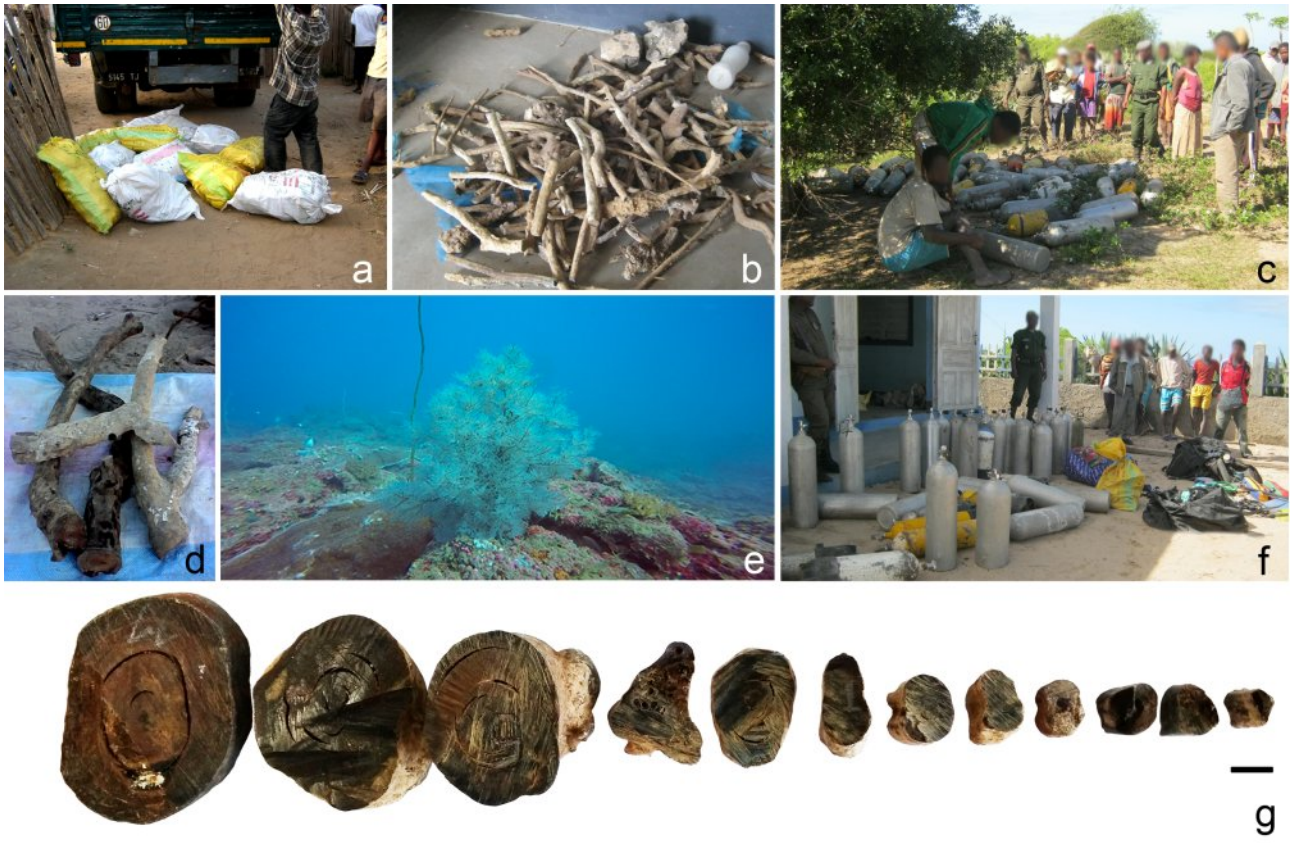

Figure 2. (a) Large bags containing dried black coral skeletons in Ambovombe, Androy. (b,d) Details of black coral skeletons collected. (c,f) Pictures of diving tanks used by poachers seized by the authorities in Kotoala, in the Ambazoa municipality of Ambovombe. (e) A branching black coral belonging to the Myriopathidae family photographed off the southwestern coast of Madagascar at approximatively 20 meters deep. This coral has the same shape and belongs to the same family as the corals harvested in Tolagnaro. (g) Pieces of black corals collected in the Anosy region showing the scale of corals that are harvested. (scale bar: 1cm)

100 kg of black coral was made in Andranobory, in the municipality of Analapatsy (Anosy region), bringing the number of official arrests in the Malagasy territory to four.

Dry tissues from these samples were also collected and fixed in 100% ethanol for DNA analysis. The primers LCOant forward and HCOant reverse were used to flank the CO-1 barcoding region (see Wagner et al. 2013 for the PCR conditions) and the same primers were used for DNA sequencing. Sequence analyses showed a high similarity with *Myriopathes* sp. and *Tanacetipathes* sp., two branched species belonging to the Myriopathidae family (Figure 2, unpublished data).

BLACK CORAL HARVESTING: AN ILLEGAL BUT LUCRATIVE BUSINESS. From the start of the operations in 2010 to today, it is known that antipatharians are collected from two regions of Madagascar: Anosy and Androy. These neighboring regions are located in the deep south of the country. They are famous for the aridity of their climate (especially in the Androy region) and the important richness of their marine resources (Bemiasa 2009). However, it is likely that harvesting of these marine resources occurs in other regions of the country. For example, in March 2012, a private operator officially requested an authorization to the Malagasy Ministry of Fishery and Aquatic Resources to collect black corals in four regions of Madagascar. The region of Androy was not targeted.

Table 1. Description of the black corals seized by the authorities in southern Madagascar. (*: given as mean ± SD; **: not sampled given that the seizure happened after the sampling date)

Date of Seizure	Sample	Weight (kg)	Diameter of base (mm)*	Length (mm)*	Region
24 March 2014	10	5	19.3 ± 5.7	199.4 ± 71.7	Androy
15 May 2014	10	163	35.7 ± 6.6	395.5 ± 97.2	Anosy
15 May 2014	10	10	12.1 ± 2.6	247.5 ± 72.6	Anosy
31 May 2015**	NA	100	NA	NA	Anosy

Information from the CSP investigations were analyzed and cross-checked with interviews of local people (boat drivers, fishermen, fishing agent services and NGO staff) liable to fishing activities. Data obtained (Table 2) were used to estimate the average amount collected by each diver, each local fish trader (at the village level) and each seller (at the national level). According to all the people questioned, poachers come mainly from China with a lot of means, vehicles and diving materials (Supplementary Material, Table S1). It is estimated that a collection of 4-5 months could lead to the production of more than 5000 kilograms of black coral. At the same time, a few farmers and managers from different regions of Madagascar made contact with universities and local authorities to obtain either authorization or license to legally collect black corals (Supplementary Material, Table S2).

In Madagascar, black corals are so lucrative that local people have named them the "rosewoods of the sea". Fishermen claim that the value of unworked black coral sold from the villages is between 10,000 to 15,000 Ariary per kilogram from scuba divers/fishermen to local collectors and 15,000 to 20,000 Ariary from local collectors to national collectors. The price per kilo from the capital Antananarivo for international exportation, mainly headed to Asia, ranges between 500,000 to 700,000 Ariary. In a country where a worker earns an average of 120,000 Ariary per month, black coral harvesting represents an assured money supply. According to Table 2, a scuba-diver harvesting black corals can earn 750,000 Ariary per day, his monthly salary reaching more or less

Table 2. Estimations of the amount of black coral collected and sold by people involved in these fisheries. (*: scuba divers are professionals external to the villages)

Source of information	Scuba divers*	Fishermen	Local fishery service	NGO people
Rule in the harvesting	Dive, collect, sale	Dive, collect, boat driver, sale	Should control trade	Interactions with people
Estimation of black coral collected per day (kg)	50 ± 10	50 to > 300	> 100	> 40
Working day per week	4 ± 2	6 ± 1	5 ± 1	NA
Duration of a harvest season	26 weeks	84 weeks	72 weeks	NA
Estimation of total black coral collected (kg)	5,200			
Region	Anosy	Androy, Anosy	Anosy	Anosy

12 million Ariary. This is higher than the salary of a government official even when all costs related to the collection of corals are deducted. This income is a thousand times higher than the monthly revenue received by a traditional fisherman in Madagascar.

ALERTS, PETITIONS AND LOBBYING. People in Madagascar have became more and more interested in the harvest and sale of black corals, which are very lucrative. Fishermen and collectors from different regions of the country have tried to gather information about the geographical distribution and the available stock of black corals. As soon as researchers and students became aware of the fisher interest, alerts and lobbying have been launched with local authorities to inform them of the illegality of these banned fisheries.

A few months later, an alert about the illegal trade of black corals in Madagascar was launched by some students who took the initiative to start a petition. The purpose of this petition was to raise awareness and put pressure on government officials to promote the rational and sustainable management of fisheries resources. The petition, which was held in two stages, first invited the authorities to sign and publish laws prohibiting the exploitation of these resources. The second stage, which was launched after the release of a Ministerial Order, invited all administrative officials involved in the exploitation of these resources, including local authorities, the regional Director of fisheries, regions, gendarmerie and the national police, customs authorities and justice, to respect and apply the laws. The petition did not collect many signatures in three months, but the actions represented students, researchers and teachers from around the world (Madagascar, France, Norway, Belgium, United States, United Kingdom and Australia). The petition has become the forerunner of a wave of advocacy and lobbying conducted by environmental civil society organizations, such as FAMARI (*Ala Fatidràn'ny Maike sy ny Riake*), AVG (Alliance *Voahary Gasy*) and the Regional Platform of Civil Society Organizations of Atsimo Andrefana, which includes more than 250 associations and NGOs as members. These organizations are among the largest and most influential in Madagascar. All these actions have together led to the signature and publication of regional and national bylaws preventing and prohibiting any form of black coral exploitation.

REGIONAL AND NATIONAL BYLAWS. Thanks to the willingness of leaders and managers of fisheries and marine resources service of the Region of Anosy, a regional bylaw suspending the collection of black corals in the region (*Région Anosy. 2013. Arrêté n° 336 REG /ANOSY du 12/12/2013 portant suspension de collecte de corail noir ou TANGOARAKY dans la Région Anosy*) was enacted. This attitude of the Anosy regional authorities was an example for all the coastal areas authorities, for the responsible management of the marine resources of Madagascar. Indeed, a few weeks after the publication of the bylaw, the presence of about 10 scuba divers and black coral collectors was confirmed by local NGOs in the Androy Region. Immediately, a regional bylaw was enacted to ban black coral harvesting in the whole region (*Région Androy. 2014. Arrêté n°021/14/REG/ANDROY/CR/Tangoharake du 5 Mars 2014 portant interdiction de collecte de corail noir ou "TANGOHARAKE" dans le littoral de la Région Androy*). However, these bylaws did not stop the illegal traffic in either regions. Scuba divers continued quietly to collect corals and civil society, including fishermen associations and NGOs, reported anonymously the arrival of professional divers in the area, with their diving materials. Nevertheless, the use of scuba is prohibited by the Article 10 of Ordinance No. 93-022 of 4 May 1993 on the regulation of fisheries and aquaculture in Madagascar. In June 2014, a ministerial decree prohibiting the exploitation of black coral at the national level was published by the ministry of aquatic resources and fisheries (bylaw No. 21816/2014 of 12 June 2014). This decree stipulates that all forms of exploitation including the extraction, collection, storage, transport, purchase and sale of black coral (Order: Antipatharia) is strictly prohibited in the whole country. The CSP and the competent fisheries authorities are empowered to note and pursue infringements.

APPLICATION OF THE LAWS: FRAGILITY AND CONSTRAINTS. The laws preventing the harvest of black coral in the natural environment constitute a tool for the government to better manage these resources. They allow local authorities and police to directly question any people whatever their role in the traffic: diver, collector, transporter or exporter. However, the traffic has not yet been affected by the publication of these laws. Indeed, anonymous informants from the Anosy and Androy regions were reporting the presence of black coral poachers. Every interviewed person refused to provide information on poachers for fear of being blackmailed or even condemned instead of them. These people included traditional fishermen, farmers, boat drivers, police, heads of regional or municipal services and researchers. Since the beginning of the traffic until June 2015, only four arrests and seizures were performed by the CSP. The most important seizure included 49 dive tanks, additional scuba equipment and an outboard engine for a speedboat (Table 2). The CSP also seized camp equipment, several saw blades used to cut the branches of corals and a weighing machine. Officially, no speedboat has been

seized. However, unofficial sources report that the arrest that led to the largest seizure also allowed the capture of two speedboats.

THE FUTURE OF BLACK CORALS IN MADAGASCAR

The efficient management of black coral is based on (1) the effectiveness of laws and rules that control the exploitation, (2) the protection of living stocks by the development of marine reserves, (3) the research on methods of transplantation in protected areas and reproduction in aquaria and (4) the awareness of populations especially via the education of children. The situation in the country since the beginning of the political and economic crisis in 2009 does not facilitate proper management. Black corals, among many other resources under CITES protection, have became indisputable objects of illegal harvesting and trade. At this time, the government of Madagascar cannot ensure the protection of these resources. The laws are not respected; and police and justice efforts are inefficient. The return of Madagascar to a constitutional political order in January 2013 constituted a new hope for the effective management of these natural resources. However, the situation has not improved. Indeed, several local sources, from the government, from NGOs or fishermen claim to be aware of several cases of law violation including the harvest, collection, sale and exportation of the resources mentioned above. Information about coral harvesting is growing over time. Corruption is one of the sources of the non-resolution of these problems of natural resource looting. Protection of black corals depends on the stability, independence and transparency of each concerned government entity, either directly or indirectly by the management of these natural resources, which are more and more in danger.

In Madagascar, the Decree No. 97-1455 of 18 December 1997, establishing general organization of maritime fishing, defines and clarifies the principles and guidelines set by Ordinance No. 93-022 of 4 May 1993 on the General regulation of fisheries and aquaculture. Figure 3 illustrates all the parts involved in the exploitation of the – unknown – natural stocks of natural resources, including black corals in Madagascar. Collection activities include purchase within a collection area, processing, storage, conditioning and/or transportation of fishery products, in order to sell them on the market, but they do not include fishing or direct capture in any form; or collection of animals from the aquatic environment. Any collecting authorization entitles the holder to the issuing of up to five collecting permits and is valid only in one zone as mentioned in the authorization. Furthermore, fishing activities are subject to the prior approval of the Ministry of Fisheries and Fish Resources. An industrial investment project (mining, fishing, production factory or else) that directly or indirectly affects the environment (including living natural resources) is subject to well defined rules. An environmental impact study is required for a large project, while for a small one, an environmental commitment program is enough. In any case, the decree of "compatibility of investments with the environment" (MECIE / Decree No. 2004-167 of 3 February 2004) governs all legal clauses that an operator must respect.

At this time, not any conservation program for black coral can be established. A better knowledge of the biology and ecology of black corals is essential to ensure an effective management of these resources. The implementation of a conservation and management program is subject to major restrictions without a basis of reliable and updated scientific data.

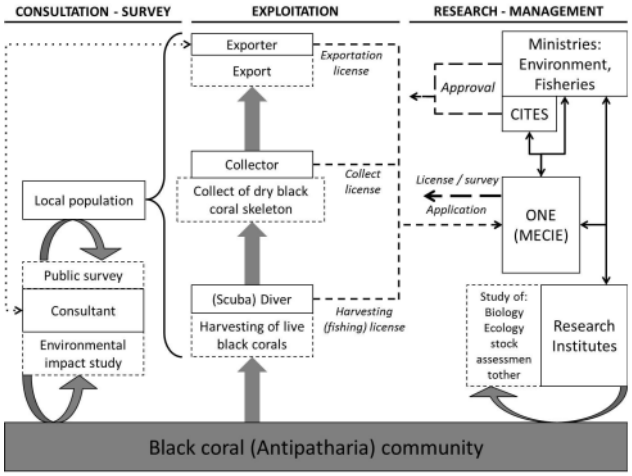

Figure 3. Diagram showing the normal procedures for black coral exploitation. The natural stock of antipatharians should be controlled through three clearly defined parts: research and management performed and ensured essentially by public centres and the government; consultation and surveys of exploitation impacts to the environment and local human societies; and exploitation itself, including harvesting, collect, transformation and exportation. Furthermore, the exploitation percentages of each part are not known yet for black corals. Meaning of the different arrows: 1- Black coral destination; 2- Application for license; 3- Approval, licensing and survey; 4- Consultancy for survey; 5- Interaction and data exchange; 6- Research and/or survey and consultation.

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SUPPLEMENTARY MATERIAL.

Available online only.

Table S1. Description of the material seized by the authorities that was used to collect black corals.

Table S2. Collection permits delivered by the ministry of fishery and aquatic resources in 2012.

ARTICLE

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The cattle raiders leave us no choice: New transhumance in the Mahafaly Plateau region in Madagascar

Johanna F. Goetter[1]

Correspondence:
Johanna F. Goetter
Department for Environmental Economics,
Brandenburg Technical University Cottbus-Senftenberg, Erich-Weinert-Straße 1,
03046 Cottbus, Germany
E-mail: goetter@b-tu.de

ABSTRACT

This article reports findings from a qualitative case study on the recent development of a pastoral transhumance movement in the Mahafaly Plateau region in Madagascar. Interviews with pastoralists from 26 villages are analyzed within a framework of contemporary new institutional economics to investigate pastoral mobility, as a response to the Madagascar-wide problem of cattle raiders (*dahalo*). The conditions for the new movement are compared to a traditional transhumance movement comprising the same actors but in reverse geographical direction. Contrary to many previous studies from Madagascar, the results reveal that property rights regarding access to ancestral land are not a constraint to pastoral mobility. The new transhumance movement was enabled by pro-social norms of solidarity, guest rights and unconditional hospitality (*fihavanana*) shared by the pastoralists in the region. Additional vital elements are mental models of kinship (*raza, longo*) and the formal indigenous institution of trust creation by sincerity oaths (*titike, kine*). However, frequent cattle raids have led to social change and an environment of mistrust; placing social constraints on pastoral mobility. Hospitality and guest rights are increasingly bound to kinship relations, and the pastoralists' interpretation of kinship has become narrower. These social constraints are far more relevant to the new movement than to the more institutionalized traditional transhumance. The findings illustrate how Madagascar's cattle raiding problem has influenced the rural society's social norms and mental models. The study highlights how supportive social norms and fitting shared mental models influence people's capacity to adapt, especially in socio-cultural settings ruled by informal indigenous institutions.

RÉSUMÉ

Dans une étude de cas qualitative, l'élaboration récente d'une transhumance pastorale à travers le plateau Mahafaly dans la région subaride du sud-ouest de Madagascar a été analysée. Des interviews ont été menées avec des bouviers de 26 villages de la région afin de comprendre comment cette nouvelle forme de transhumance est apparue et comment elle a été élaborée afin d'identifier les similarités et les différences par rapport à la transhumance traditionnelle qui reste d'actualité et suit la même direction mais en sens opposé. Les interviews ont abordé les expériences personnelles des bouviers sur la pratique de la nouvelle transhumance ou la transhumance traditionnelle ainsi que leur perception des menaces que représentent les voleurs de bétail (*dahalo*, en dialecte régionale *malaso*). Les avantages et les limites de la nouvelle transhumance ont également été globalement abordés. Les personnes résidentes de la zone littorale ont été interviewées pour comprendre comment elles percevaient la nouvelle transhumance et comment elles accueillaient les bouviers dans leurs villages. Contrairement à de nombreuses études menées à Madagascar, les résultats obtenus ici montrent que les droits de propriété portant sur l'accès aux terres ancestrales ne sont pas une contrainte pour les mouvements pastoraux. La nouvelle forme de transhumance est encore peu institutionnalisée mais favorisée par des normes pro-sociales de solidarité et d'hospitalité inconditionnelle (*fihavanana*, en dialecte régionale *filongoa*), de partage des ressources fourragères, de modèles mentaux de liens de parenté (*raza, longo*) et d'institutions autochtones formelles régissant les rapports de confiance mutuelle (*titike, kine*). Néanmoins, l'extension et une plus grande institutionnalisation de la nouvelle transhumance sont limitées par les modèles mentaux portant sur les droits des bouviers ainsi que par les changements sociaux induits par la forte croissance des vols de bétail, de sorte les institutions qui régulent la mobilité des bouviers sont affaiblies. L'hospitalité et les droits minimums sont de plus en plus limités aux relations filiales, et leur interprétation en ce qui concerne les bouviers a été bien réduite avec un accueil refroidi en ce qui concerne les bouviers allochtones, plus particulièrement sur la nouvelle transhumance. Cette étude montre comment les problèmes de transhumance du bétail ont influencé les normes sociales et les modèles mentaux des sociétés rurales. Elle

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a révélé la manière avec laquelle des normes sociales et des modèles mentaux spécifiques influencent la capacité d'adaptation des gens, plus particulièrement dans des milieux socio-culturels gouvernés par des institutions locales informelles.

INTRODUCTION

Pastoralists around the world are known to adopt flexible management approaches to cope with unexpected events and changing livestock-raising conditions (Fernandez-Gimenez and Le Febre 2006). One important strategy for coping with variable water and pasture availability is pastoral mobility, including long-range, predictable seasonal movements called transhumance (Behnke et al. 2011). In the Mahafaly Plateau region of southwest Madagascar, the Tanalana people living on the coastal plain still practice their ancient tradition of transhumance (Battistini 1964). The Tanalana herders spend approximately four to six months of the year further inland on the plateau, where fodder is comparatively more abundant (SULAMA 2011). In recent years, a previously unreported transhumance movement in the inverse direction to the traditional one has emerged: in order to escape cattle raiders, herders from the plateau temporarily move to the coastal plain. This pattern will hereafter be referred to as 'inverse transhumance'.

Cattle raiding has been known as a feature of pastoral life in Madagascar since the publication of Robert Drury's Journal (Defoe et al. 1890). Since then, it has appeared in the literature with increasing frequency (Ribar 1926, Faublée 1941, Michel 1957, Rabearison 1965, Randrianjafizanaka 1973, Randrianarison 1976, Hoerner 1982, Fieloux 1987, Fauroux 1989, Elli 1993, Kaufmann 1998, de Saint-Sauveur 2002, Fauroux 2003, Rasamoelina 2006, McNair 2008, Rakoto 2010, 2011, Scheidecker 2014). In the past, cattle raiding had mainly cultural motives (Fauroux 1989). Cattle are the main source of capital and social status in the Mahafaly Plateau region (Fauroux 1997), and stealing them has long been a 'local sport' of young men (Battistini 1964). Today, however, attacks by organized gangs of cattle raiders, so called *dahalo* or *malaso*, have reached new dimensions in terms of economic impact and violence in Madagascar. In the most affected southern regions, their attacks have led to the displacement of villagers (OCHA 2012), and to an overall decline in economic activity (Fafchamps and Minten 2006, Rakoto 2010). Cattle raiding has become a topic frequently discussed in the national and even international media (cf. BBC News 2008).

Although a small number of studies on local adaptation to cattle raiding in Madagascar do exist (de Saint-Sauveur 2002, Tubau 2011), new pastoral movements have not been reported to date. On a global level, cattle raiding is known to affect many pastoral groups, mostly in Africa (Blench 2001, Bollig 2006, Beyene 2009, Schilling et al. 2012). Yet recent trends towards greater pastoral mobility have mainly been described as climate change adaptation strategies (Agrawal 2010, Scheffran et al. 2011, Upton 2012).

This case study analyzes the factors that enable, shape, and restrict the emergence of the inverse transhumance movement from the Mahafaly Plateau to the coastal region. In Madagascar, access to pastoral land in general also means access to 'ancestral land'. This *tanin-drazana* is understood as "(…) part of Madagascar's national motto, with the zebu cattle as its emblem" (von Heland and Folke 2014: 259). Customary property rights and legitimate use of ancestral land are typically limited to the members of the local 'autochthonous' clans (Muttenzer 2006, Evers and Seagle 2012). Access and rights to land for newcomers and evolving conflicts with the owning clans are mainly solved by formal agreements of clan councils (von Heland and Folke 2014). In the study area's coastal region, access to land and especially to scarce fodder stocks is a source of frequent conflict. It is thus expected that the moving herders' need to obtain a share of these fodder stocks will require additional formal agreements with the communities living on the coastal plain.

Pastoral societies in Madagascar and other regions, however, do not principally base pastoral mobility, and the related access to resources on such formal agreements alone. Essentially, in most pastoral societies the boundaries of resource territories are flexible, the conceptions of legitimate user groups are fuzzy (Bromley 2006, Fernandez-Gimenez and Le Febre 2006), and the relationships between interacting groups of herders are dominated by solidarity, reciprocity, and kinship (Thébaud and Batterbury 2001, Bollig 2006, Di Falco and Bulte 2013). In Madagascar, the "social cornerstone" of the society (Fritz-Vietta et al. 2009: 93) is the concept of *fihavanana*, embracing meanings of solidarity, social harmony, tolerance, friendship, union, mutual responsibility, reciprocity and kinship (Evers 2006, Schachenmann 2006, Fritz-Vietta et al. 2011, Kneitz 2014).

Alongside the social value of *fihavanana* and formal laws and rules on land and resources, the inverse transhumance movement is expected to be shaped by additional factors. People's adaptation options are known to be influenced by a range of social and personal variables that include knowledge, risk perception, moral values, habits, social status, power relations and traditional group procedures (Adger et al. 2009). To analyze the broad spectrum of factors outlined above, a framework from 'contemporary new institutional economics' (Vatn 2005) was chosen: Social interaction, but also all other behaviors of individuals, is explained as being structured and regulated by so-called institutions in the form of rules, values, routines, norms and mental models.

The paper is divided into three parts. The first part describes the conceptual framework and methods, and gives an introduction to the study area. The second part presents the data on inverse transhumance, as well as an overview of traditional transhumance, the local perception of cattle raiding, and ongoing social change. The final part discusses the character, conditions and limitations of inverse transhumance in comparison to traditional transhumance and in relation to the raiding problem and social change.

METHODOLOGY

CONCEPTUAL FRAMEWORK. Within the framework of contemporary new institutional economics (Vatn 2005) adopted here, the action of an individual is seen as being embedded in a web of institutions. These institutions on the one hand constrain certain patterns of behavior, but on the other hand enable other patterns. They allow the individuals to predict the likely behavior of others and adapt their own behavior to one that is supposedly socially accepted (Dequech 2006). Institutions can be classified according to their degree of formality: Formal institutions are understood as socially transmitted and customary normative injunctions evidently known to the individual (Hodgson 2006). Along the same lines, formal institutions are legal rules which are created and enforced through sanctioning by some explicit collective process (Knight and Sened 1995, Schmid 2004), in the Malagasy

context, for example, the local rules created by the village communities (*dina*). Informal institutions are immanent normative dispositions (Hodgson 2006). Deviations to informal institutions cannot be formally sanctioned, but their enforcement relies on expressed disapproval of other individuals, for example, through gossip and ostracism (Schmid 2004, Eggertsson 2013). Informal institutions include codes of conduct, customs, routines, shared mental models and social norms, the latter being defined as "social standards of behavior and/or thought" (Dequech 2006: 473). Mental models represent the people's beliefs, interpretations of the world, and views of causal relationships (Denzau and North 1994, Bromley 2006). Mental models can be seen as "the crucial factor in explaining the choices people make" (Knight and North 1997: 216) and as enhancing the "durability, power, and normative authority" of all other types of institutions, while the other way round those institutions standardize mental models by creating "strong mechanisms of conformism and normative agreement" (Hodgson 2006: 7). As an example of informal institutions, the Malagasy concept of *fihavanana* embraces mental models about the definition or character of kinship, friendship and hospitality, and related social norms that define what good behavior in line with *fihavanana* means.

Processes of institutional change and the emergence of institutions differ between formal and informal institutions: A formal institution is consciously crafted and changed, for example, by copying another institution from a different setting (Ostrom 2005). Alternatively, people implicitly use their underlying mental models to gradually adapt an institution until they feel that it 'fits' again (Mantzavinos et al. 2004, Brousseau et al. 2011). The change and adaptation of informal institutions is driven by learning, changes in the power of actors, and the institutions' functionality (Schmid 2004). Informal institutions, especially social norms or customs can even "die in an evolutionary process (…) without people being aware of the process" (Schmid 2004: 7, 267).

STUDY AREA. The Mahafaly Plateau region is situated in southwest Madagascar, in the dry forest ecoregion south of Toliara. The region can be divided into two zones: the plateau itself and the coastal plain.

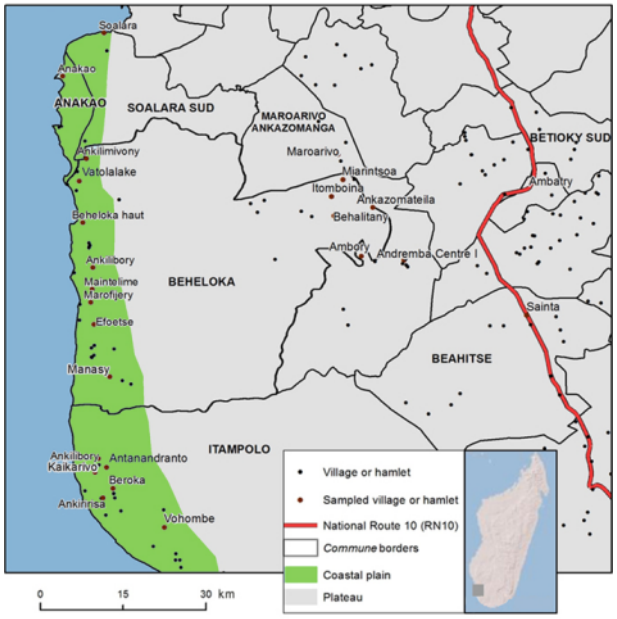

Figure 1: Map of the study region and sampled villages and hamlets (source: SuLaMa).

According to the official ethnic classification of Madagascar, the region is mainly inhabited by the agro-pastoral group of Mahafaly and its sub-group of Tanalana (Battistini 1964). However, during field research, people clearly expressed a local view of Tanalana as an independent group. According to the villagers' classification, the agro-pastoralists on the coastal plain are Tanalana, while the villages on the plateau are both mixed and pure Tanalana and Mahafaly communities. The semi-nomadic Vezo fishermen are another ethnic group living in the region. Inter-ethnic and inter-regional marriages are common and create vast familial bonds between people of different regions and ethnic groups.

The Tanalana and Mahafaly people are subsistence farmers and also engage in keeping poultry, goats, sheep and zebu-cattle (*Bos indica*) (Battistini 1964, SULAMA 2011). The Tanalana villages on the plateau were founded around two generations ago, by Tanalana people from the coastal plain who moved in search of better conditions for agriculture and livestock keeping (Esoavelomandroso 1989). The predominantly red soils and precipitation rates between 400–450 mm/year on the plateau allow better yields than on the coastal plain with only 300–350mm/year and sandy soils. On the plateau, the wide savannas allow cattle to graze freely the whole year round.

On the coastal plain, grass quantity and quality allow grazing for only around two months of the year. For four to six months, the cattle are fed on sliced branches of planted *raketa* cactus (*Opuntia* spp.), and wild or planted *samata* trees (*Euphorbia stenoclada*, Figure 2). In order to stimulate the growth of *samata*, the herders have been removing other shrubs, turning the region into a "*samata* landscape" (Kaufmann 2004: 351).

Livestock is the fundamental form of material wealth in the region (Fauroux 1997, Hänke and Barkmann, In litt.). In 2012, approximately 60% of the region's households owned livestock, but only 40% of the households were able to raise cattle. Depending on the family's economic situation, the number of cattle per household varies between 1 and more than 200 animals, with an average of 17 heads (Neudert et al. 2015). Raising cattle is a family affair, where the animals are generally herded by the sons while ownership and decision rights are mainly in hands of the father.

The social and political organization of the Tanalana and Mahafaly people is based both on the traditional ethnic structure of common ancestors (*raza*) with clans and subordinated lineages,

Figure 2: Cattle eating chopped *samata* (*Euphorbia stenoclada*).

as well as the territorial structures of the state-run administration. The smallest administrative unit in Madagascar is the *fokontany*. It usually covers a village and its surrounding hamlets. A *fokontany* is officially run and represented by a selected head (*chef de fokontany*). Decisions on the village level are however mainly taken by the village community (*fokonolo*) in open meetings or the group of elders. The villagers rely mainly on two groups of social networks: their formal kin group (*raza*) and the *longo*. In the study region, unlike other parts of Madagascar (Astuti 1995), *longo* is not used as a synonym for the formal kin group comprising people from the extended family up to the overall ethnic group (Eggert 1986). *Longo* describes a personified kin group consisting of relatives, friends and in general all people with whom one has a good relationship (*fihavanana*, in the regional dialect *filongoa*). In Madagascar, the character of kinship is 'cumulative' (Southall 1986, Astuti 1995), allowing new alliances for example by marriage or the birth of children. Identity and kinship are understood in a broad sense of being created throughout one's life and "settled definitely perhaps only some considerable time after death" (Bloch 2005: 65). Identity is "fluid" (Marcus 2008: 88), changing with a persons' environment, association, choice and need (Bloch 2005, Marcus 2008).

INTERVIEWS. The study was conducted during three periods of field research in 2012 and 2013, preceded by a preparatory field trip in 2011. The analysis is based on 81 open and semi-structured interviews with people from 10 villages on the plateau and 16 villages on the coastal plain (Figure 1).

Moving herders and cattle owners from the plateau and the coastal plain were interviewed about the transhumance movements in general and their personal ways of conducting the move. The conversations covered the choice of destinations, courses of action, related customs, costs, property rights to fodder, and the feeling of living temporarily 'abroad'. Non-moving herders on the plateau were interviewed about their reasons for not migrating. People of the coastal plain were asked their opinion about hosting the new guest herders in their village. The perception of the problem of cattle raiding was also discussed. The interviewees were, with five exceptions, males. Ages ranged between 15 and 88, with the majority being between 30 and 60 years old.

All interviews were held by the author with the help of research assistants consecutively interpreting between the local Malagasy dialect and English. Both assistants knew the dialect very well, as one grew up on the plateau, and the other has been working in the study area since 2011 and living in Toliara since 2004. Cattle owners and herders were identified with the help of local guides. Most interviews were held in the presence of the author, an assistant, a guide and one interviewee. The guides were mostly young men under 20 who did not participate in the interviews. In three interviews, however, two older guides (age 37 and 57) added information and views, and in one case took over the interview with a teenager. Two interviews were held with two close relatives (father and son, couple), and four interviews with two, two interviews with three, and six interviews with four or more people who happened to be together at the time of interview.

During the interviews, comprehensive, often word-for-word notes were taken. The notes were then digitally transcribed by the author, and if required replenished by the interpreter with help of audio-records of the interviews. An inductive content analysis (Patton 2002) was done using the QDA software Atlas.ti to code and theme the transcribed data. The analysis is underpinned with some data from a region-wide household survey undertaken in 2012 (Neudert et al. 2015).

RESULTS

CATTLE RAIDING AND SOCIAL CHANGE. In the perception of all interviewees, the problem of cattle raiding started recently or has at least increased a lot in the last decades (Supplementary Material). As most interviewees agreed, cattle raids have always taken place in the region, but today the raiders would even "kill the people" and "steal the chickens". Of the interviewed plateau villagers, 11 had already been victims of raids, several more than once. All others reported raids having happened to relatives or other villagers. According to the interviewees, raiding is today mainly done by armed gangs from the neighboring Onilahy region northwest of the plateau. Cattle raids are far less frequent on the coastal plain, probably because the Onilahy region is farther away. The raiders attack especially in the dry season when the water level of the Onilahy River is low and it is easy to cross. Some communities on the plateau have recently employed soldiers or gendarmes to protect their people and animals. Nevertheless, most people are still very frightened of the raiders as they are said to wear extremely powerful talismans (*odigasy*) and thus survive all shootings without any wounds.

Asked about the reason for the increase in raids, the people of the coastal plain mainly accused state agencies and the government of not combating the raiders and of being idle or corrupt, however without mentioning the 2009 political crisis. Increased cattle raiding is also perceived as associated with a general process of social change: The plateau villagers more often blamed the 'bad youth', reporting that many young men make friends with suspicious strangers and serve them as drivers providing information about the whereabouts of the local cattle herds. Others are said to squander their money and then search for opportunities to make a fast profit by stealing on their own or at the command of a gang leader. Interviewees throughout the study area complained that the youth pay no heed to their parents' or elder's reprimands for stealing or other bad behavior: "It is a problem of generation. The sons of parents are strong now, they decide to steal." (58: 45, male, age: 60). "In the past, the children respected their parents (…) But today, the children even kill their parents when these try to intervene." (102: 1, male, age: around 20).

Throughout the region, the fear of having one's cattle stolen by order of an envious villager is commonly reported. A general rise in envy and 'bad spirits' was noted, coupled with a loss of social cohesion and traditional values like altruism, solidarity and helpfulness: "Before, the relationship and living together of the people (…) was important and strong, (…) today people don't care much about life in the community and the relationships are frail, even inside the family." [76:51, female, age: 17]. Statements like "the people do not love each other anymore" (*fa tsy mifankatea sasy ty ndaty*) were often made and explained as the result of modern times where people "think they are independent" and only "do what they want".

Although the coastal plain is primarily affected by clandestine theft rather than violent raiding, many stories about attacks on the plateau by infamous raiders circulate even here. Thus, the people are increasingly wary of all strangers and poten-

tial local 'chauffeurs'. In February 2013, a ritual of sincerity oaths (*titike*) was organized in order to prevent an involvement of the Tanalana people in raids. *Titike* are traditionally realized on the level of a village community. This time, however, it embraced all Tanalana clans. On the plateau, such sincerity oaths (here also called *kine*) were also realized frequently, but did not go beyond the village level. Some plateau interviewees lamented that the *titike* would anyway no longer have the expected effects, as many young men do not believe in it, or if so, would avoid taking part.

TRADITIONAL TRANSHUMANCE FROM THE COASTAL PLAIN TO THE PLATEAU. Reasons for moving and time frames: Traditionally, the cattle of the coastal plain are moved to the plateau every year in the practice of transhumance (excluding chard oxen). Only rarely, when the plateau's grass was worse or the coastal grass better than usual, did some herders decide not to move. Today, for fear of raids on the plateau, some herders decided not to move anymore or not every year. From a sample of 90 cattle owners from five villages of the Commune of Beheloke (unpubl. survey data from 2012), 73% send their cattle on transhumance every year, 9% less frequently, and 12% never. The average size of herds that never move is much smaller (2.5 heads) than that of herds that do move (17.7 heads). The transhumance season starts at the end of November or beginning of December, when the quality of coastal grass and *samata* fodder is low, but the beginning of rainfall on the plateau promises good-quality grass there. Traditionally, the herders return between May and June. Since around the year 2010, the rising incidence of raider attacks on the plateau has prompted many coastal herders to return home earlier (between January and April).

Conditions for staying on the plateau: The herders' journey from their home villages to the destinations on the plateau takes about one-and-a-half to two days by foot (between 40 and 70 kilometers). All movements back and forth between the home village and those destinations have to be officially permitted and registered by the respective *chefs de fokontany* in every herder's personal 'passport' (*pasiporon-dia*). This exercise book with officially stamped entries for every adult man or woman was regionally introduced in order to enhance security, and especially to prevent trafficking in stolen cattle. Officially, it should document the authorization and realization of all movements between villages, as well as selling of animals. In practice, registration in the passport is often only considered necessary by the hosts and the guest herders when these are not yet personally known in the village. The 200 Malagasy Ariary ($US = 3,097 Ariary, 9 October 2015) paid per registration are the only fees related to transhumance. Only for the destination of Andremba were there reports that in order to ensure a good relationship, some herders arriving for the first time voluntarily offered money or a goat to the local community. Recently, many cattle owners engage a non-local policeman or soldier (from Toliara or Betioke) to protect their herd during the stay on the plateau. As this can cost up to 200,000 Ariary per month, some cattle owners share the costs by joining their herds.

There are no special guest rules that the herders have to follow when staying on the plateau. Local ancestral or community rules (*lilyn-draza, dina*), customs (*fomba*) and common expectations about good behavior are the same as on the coastal plain. It was reported that sometimes groups of newcomers performed the common ritual of sincerity oaths (*titike*) with the host community. However, this ritual is seldom perceived as necessary because herders are only considered to be real newcomers when neither they nor their close relatives or ancestors have stayed in the village before: "The *raza* [kin group, clan] is already staying here since long ago, so everybody can come and stay just like this. But the really new people should show their passport and do a *titike*." [45: 29, age: 55].

The Tanalana people from the coastal plain are guests both in villages inhabited mainly by Tanalana, as well as by Mahafaly people. Their relationship is closest with the Tanalana villages. Interviewees from both the coastal plain and the plateau considered all Tanalana people as descendants of the same ancestors, and therefore 'all one kin'. This formal kin group (*raza*) was sometimes expanded to all people from the Mahafaly Plateau region. The interviewed host villagers practically did not perceive any herder as completely unfamiliar or un-kin, as they were said to be at least 'a *longo* (friend or relative) of somebody' or 'known'. However, it was never stated that being kin or 'known' was a prerequisite for staying somewhere; on the contrary this was denied: "Some have [*longo* here], others don't. They just follow their friends from the coastal plain coming here." [79: 97, age: 62]. "[Somebody without *longo* here] must go to the *chef de fokontany* and say "I want to stay with my cattle here, and as I have no father or mother here, you are my family." [68: 42, age: 57].

Choosing destinations: During their stay on the plateau, most herders spend the night outside on the grazing grounds. The herders have the right to select their grazing areas freely and use fodder and water free of charge. The few big plateau villages like Itomboina or Andremba are frequented by hundreds of herders from the coastal plain and in some hamlets the number of guests exceeds the number of villagers. Most herders only frequent a small set of neighboring villages with choices being based mainly on practical considerations, especially travelling distance, the local availability of fodder and water, and, more recently, also the local security situation. Villages with a reputation for being risky became visited less (e.g., Andremba) or not at all (e.g., Ambatry). Among the more secure villages with good grass and water supply, many herders choose a place where they have longo. If the herders fall victim to raids, the *longo* are expected to help them to get the stolen animals back. In general, interviewees did not make a distinction between *longo* in the sense of relatives or in the sense of friends. Only three interviewees stated that they no longer consider their friend-*longo* on the plateau as real *longo*, due to their belief that in the current situation of general insecurity on the plateau, even their friends might be capable of stealing their cattle. Besides the practical considerations for choosing a destination, for some herders the most important factor is that they follow their personal or ancestral tradition or custom (*fomba, fomban-draza*): "It does not [depend on *longo*], it depends on your *fomba* [where to go]." [84: 10, male, age: 49].

INVERSE TRANSHUMANCE FROM THE PLATEAU TO THE COASTAL PLAIN. Reasons for moving and time frames: The transhumance movement in inverse direction from the plateau to the coastal plain turned out to have started as far back as 30 years ago (Supplementary Material). However, unlike the situation today, only a small number of Tanalana herders from Miarentsoa and Itomboina were involved at that time. Those herders were said to be motivated by the coastal plain's good conditions for cattle raising, specifically the coastal fodder plants (*samata*) and a

higher and thus healthier salt content in the water holes. In the 1990s, recurring droughts on the plateau prompted more herders to move to the coastal plain. Since 2000, and especially since 2010, this movement has gained pace and escaping the raiders has become the crucial motive.

At the time of the fieldwork, whether herders go on inverse transhumance or not is highly varied between different villages and ethnic groups. In the Tanalana villages of Itomboina and Miarentsoa the majority of herders practice inverse transhumance: of the 31 cattle-raising households sampled during the 2012 household survey, 16 move every year, three occasionally, and only 12 never. Of the 19 households that do move, five declared that they had done so "less than five years ago", two "less than 10 years ago" and 12 "more than 10 years ago". Those people who decide not to move have on average smaller herds than those who do move (13 versus 20 heads in Miarentsoa, and four versus 19 heads in Itomboina).

Most of the interviewed herders practicing inverse transhumance reported that today moving is no longer optional, but that "the raiders leave us no choice" [24: 37, male, age: around 60]. Nevertheless, in many Mahafaly villages it is only single herders that move (e.g., in Maroarivo), and in the big Mahafaly village, Andremba Centre I, no herder going on inverse transhumance could be found.

Herders who started to move comparatively early were asked if they had shared their experience and reported to have only talked with close family members. On the other hand, asked how they got the idea or made the decision to start moving, herders only rarely explained that their start was triggered by the experience of other moving herders. One interviewee, the first moving herder from a Mahafaly village, explained that he had formed the idea while observing herders on traditional transhumance. Two interviewees stated that going on transhumance to the coastal plain was their *fomba* (tradition/custom), although with very different time references: While a group of interviewees reported the existence of a *fomba* since the time of their grandfathers, a couple declared moving to their ancestors' place on the coastal plain for four years as their *fomba*. Regarding the general understanding of *fomba*, many interviewees presented the perception that *fomba* are not stable or necessarily long-standing, and that 'new *fomba*' easily emerge, often out of 'old *fomba*' that change following 'the life of the people' and 'the development'.

The moving herders leave the plateau between April and August. The dates for moving back and forth and the overall duration of inverse transhumance (between two and ten months), are decided individually by the herders. Factors taken into account are, first, the security situation on the plateau (rumors about raiding attacks, existence of soldiers in the home village), second, the resource endowments for buying fodder on the coastal plain, and third, perceiving transhumance as a burden, for example due to being away from one's 'own country'.

Conditions for staying on the coastal plain: Similar to traditional transhumance procedures, plateau herders moving to the coastal plain need to register with their 'passport' at the *chefs de fokontany*. Both for transhumance guests on the plateau as well as guests on the coastal plain the registration was predominantly described as some kind of 'annoying duty', but never as a constraint to transhumance or mobility in general. One interviewee from the coastal plain reported the case of plateau herders staying in the bush and avoiding entering the village (and thus having to register), probably because their herds comprised stolen animals.

After arriving in a host village, nearly all herders have to perform the traditional ritual of sincerity oaths (*titike*) to build mutual trust with the villagers. Unlike the situation during traditional transhumance on the plateau, where most herders can build on a *titike* ritual already performed by their relatives or ancestors, the *titike* ritual is frequently performed on the coastal plain. On the plateau, the few *titike* rituals performed today are mainly held by groups of 'newcomers' rather than individuals, but this is not feasible in the case of inverse transhumance. On the coastal plain, the rituals are performed by individual herders, firstly, because the herders' individual first arrival in a village varies highly in year and month and, secondly, because the comparatively small number of moving plateau herders are dispersed among more than 30 coastal villages, so that there are only between one and ten guest herders per village. The villagers do not demand a *titike* from the many fodder guests from other coastal villages. In the view of one *chef de fokontany* from the coastal plain, the reason for this difference is that people from the plateau are "more often friends of raiders" [84: 9, male, age: 49].

Unlike traditional transhumance, moving herders spend the night inside the village with their *longo* or in their own hut. Water is free of charge, but most fodder has to be bought. Fodder consists of private stocks of *raketa* (prickly pear), and privately as well as commonly owned *samata* trees. *Samata* is mostly preferred over cactus, as the latter is more expensive and besides chaffing also requires burning off the spines. The open-access community stocks are generally depleted after the first month of the feeding season, so that most plateau herders can use them only in the first days or weeks after their arrival. If economically possible, many also prefer to feed exclusively bought private fodder that is generally of better quality. Prices are determined principally by negotiation between seller and buyer and the overall supply in the village. The reported prices for an amount of *samata* that feeds 15 cattle for 5 months range between 17,250 and 855,000 Ariary or, if paid in cattle, between 0.2 and 6.3 animals (mainly two-year old animals). According to interviewees, an increasing scarcity has led to a considerable rise in prices in the last five years. Herders living for many months in the same village reported having received a piece of agricultural field from their *longo*, but had never established their own fodder plantation.

Traditionally, the use of the community stocks is free for all guests, regardless of their ethnic group or *longo* relations. Many locals claimed that the guests selfishly overuse the *samata* trees, irrespective of whether they came from the plateau or another coastal village. However, most interviewees argued that the community stocks should be kept open to all guests and only one person directly expressed a wish to limit the use of community stocks to residents. While the villagers work on the establishment and enforcement of local community rules (*dina*) for the distribution of *samata* among themselves, the topic of guests' rights had not been discussed up to the time of the fieldwork.

Choosing destinations: In contrast to traditional transhumance, there is no pattern of every plateau village being linked to a typical transhumance destination on the coastal plain. Many herders also shift between several villages in search of good, cheap cattle fodder. Besides personal fodder purchasing capacity,

the destinations are individually chosen on the basis of the walking distance from home and the existence of some kind of *longo*.

Impediments to moving and kinship relations as a precondition: Although all the interviewed moving herders do in fact stay at the place of some *longo* (principally family in law), their personal views on the importance of having *longo* or not having *longo* being an impediment to going somewhere are highly contrasting. The same variation in arguments and opinions was found among interviewed inhabitants of the coastal plain. The interviews did not reveal any differences between the views of people from the coastal plain versus the plateau, or any other pattern (e.g., younger versus older people). The following section presents the stated opinions in detail, first from the perspective of being a guest on the coastal plain, and then from the perspective of hosting herders from the plateau.

The perspective of plateau people as potential guests. Similar to traditional transhumance, staying with *longo* is the *fomba* and makes organizing one's stay much easier. But even more importantly, many moving herders claimed that only their *longo* would help them if a problem arose, or that they did not trust other people: "You can't go where you don't have *longo* […Only] the *longo* don't kill you." [87: 26, male, age: over 50]. The importance of *longo* was however also directly rejected: "[Where to go] is not a question of *longo*, but of fodder." [23: 32, male, age: 50]. Given the importance of longo as discussed by moving herders, one would expect this aspect to arise in the discussion with non-moving herders. However, only one interviewee directly argued that he had no trustworthy longo on the coastal plain and thus no destination to go to. All other interviewees, including those from Andremba Centre; where up to the time of the fieldwork nobody had moved, did not cite lacking security given by their longo as part of their personal reasoning. This type of impediment was only mentioned by those not personally affected: "Some people here don't go anywhere (…) It is not good when you go where you don't have *longo*, because then you are scared." [88: 5, male, age: 55]. Other interviewees stated that it would indeed be strange to stay somewhere without knowing anybody, both for themselves and for the host community. However, this would not be an impediment, as all plateau herders had at least one friend somewhere on the coastal plain or could make one for that purpose. Only one person who did not move claimed that it was not enough to have friends to stay with, and that one needed relatives: "Your friend might inform the raider to steal your cattle. So now, we don't trust the friends anymore, because this happened to four people from here." [86: 9, male, age: 33].

Besides enjoying greater comfort and security when staying in a village with *longo*, several interviewees from the coastal plain also argued that having *longo* is a prerequisite for the right to stay. In turn, on the plateau, this type of impediment was only brought up on enquiry, and only acknowledged for people from other villages: "Here, there is no problem, because people from the coastal plain come here [Andremba], and people from here [neighboring Ankilimasy] go there. But there are no people from the coastal plain going to Maroarivo, so for people from there it's different." [95: 7, age: 46]. "The people from north of Andremba are not originally from the coastal plain and so they don't have family there, and so the villagers don't know them and might think they arrived in order to steal their cattle. (…) When the first person from Maroarivo arrived there, the community (…) told him not to come back again." [73: 67, age 57]. Other people however argued that a general guest right to stay somewhere does indeed theoretically exist, but has no practical relevance due to the high level of familiarity among all people of the region: "[A:] People without *longo* can also go there, they just stop at the *chef de fokontany* and he shows them a family to stay with, and then (…) he makes a *titike*-ritual (…) But this is a rare case, because all people have *longo* there. [B:] Maybe for people from very far away it is different, like for people from [the commune of] Masiaboay." [50: 39, age A: around 60, age B: 57].

When asked to give their personal reasons for not moving, the non-moving herders mostly explained that their animals were unable to cope with the *samata* fodder and the salty water at the coast: "The coastal plain is my ancestor's land, but my cattle can't adapt to it." [80: 38, male, age: 39]. This impediment for moving was also cited by villagers of Itomboina and Miarentsoa, both villages where the first herders had in fact started moving to benefit from the specific conditions at the coast. A number of people stated particular reasons for not moving: their own village on the plateau was safe enough, the coastal plain was just as risky as the plateau, being a victim of raids was destiny or a decision of God, cattle raiders would only attack 'bad people', and one declared he was not able to even temporarily migrate from the land of his ancestors.

The perspective of people from the coastal plain as potential hosts. In the coastal plain region, all interviewees stated that the plateau herders staying in their village were *longo* of another villager. The question of whether, theoretically, herders without *longo* would also be allowed to stay was answered with inconsistent arguments, similar to those given by the plateau people. Some declared that, in general, every unsuspicious herder arriving from the plateau would be received regardless of being a *longo* or not: "Everybody from there with a clean passport [i.e., without inconsistencies] is welcomed here." [85: 15, male, age: 54]. This was sometimes specified with the argument that the same plateau villagers also host people from the coast on transhumance: "Today, the people from there replicate what we did: We went there and were welcomed, now it is the other way round." [21: 22, male, age around 40]. When asked why there are only Tanalana but no Mahafaly guest herders staying in their village, the interviewees from the coastal plain mainly argued that the Mahafaly people 'don't have the custom' of going to the coastal plain, or – echoing the non-moving plateau herders – that the plateau cattle are not able to digest *samata*. Others stated that only Tanalana people or the villagers' *longo* should be guests, or argued in the sense that all Tanalana are *longo* or known everywhere: "All people from Miarentsoa [Tanalana-village] know all people on the coastal plain, so they can go everywhere. If you know one or more persons here, you can tell them that you come here for the *samata*, that's okay." [42: 63, male, age: 50–60].

Limitations of a general guest right to stay somewhere were mainly related to the fear of cattle raiders from the plateau. One *chef de fokontany* reported that his village community had denied permission to stay to two herders without *longo* who had come from a commune further away than usual (Beahitse). He argued that the villagers would receive *longo* according to the ancestors' custom (*fomba*), but would not welcome unknown people as they "don't like raiders". Residents of another village repeatedly

claimed that they would not accept any guests from the plateau, accusing the guests of not following the local rules of good behavior. However, according to other interviewees there are indeed guest herders from the plateau staying in that village.

DISCUSSION

The case study compared two current transhumance movements within the same region in southwest Madagascar: The traditional one from the coastal plain to the plateau, and the comparatively new one in the inverse direction from the plateau to the coastal plain. The results reveal that the two patterns differ only slightly in terms of their practical realization, but are highly variable between individuals. These variabilities are mainly rooted in the cattle herders' personal decisions about where, when and for how long they will move. For traditional transhumance, these decisions are mainly taken on the basis of technical factors like water and fodder availability, security, and logistics. In turn, inverse transhumance movements are to a far greater extent determined and constrained by informal institutions, especially mental models regarding concepts of hospitality, guest rights and kinship. As a consequence of differing personal interpretations of these concepts, the transhumance to the coastal plain is not undertaken by all potential participants who would gain from it in terms of security against cattle raiders. The following section discusses the institutional constraints on participation in inverse transhumance on the one hand, as well as the aspects that enabled the establishment of the movement on the other hand.

PROCEDURAL LIBERTY, MOBILITY, AND RISK PERCEPTION. The inverse transhumance movement did not emerge through some process of collective decision-making on the village or clan level, but through the decisions of individual herders to start moving. The movement's development was facilitated by the herders' procedural liberty to start moving without the need for coordination with others outside the core family, and without having to wait for the establishment of some kind of formal agreement. There are also no social norms or taboos (*fady*) that restrain the move. The plateau herders arriving on the coastal plain were able to make use of region-wide institutions already used in the context of traditional transhumance, especially the sincerity oaths (*titike, kine*). Therefore, no formal agreements between plateau and coastal plain communities had to be established to allow the plateau herders to stay on the coastal plain. Also, for the annual moves, no local, regional or national formal institutions have to be considered, apart from the duty to register the stay in every herder's 'passport' at the *chefs de fokontany*.

The literature about the study area mentions frequent migration patterns not addressed in the interviews: Many women marry into another village, men temporarily move inside or outside regions to carry out slash-and-burn agriculture (SULAMA 2011) or to take up temporary employment (Neudert et al. 2015). Regional droughts and famines trigger the final out-migration of whole families (Kaufmann and Tsirahamba 2006). This overall high mobility supports taking a temporary move into account when searching for strategies for coping with raids. Not surprisingly, being bound to one's ancestral land was stated only once.

The main reason stated for not moving was the cattle's adaptation problems to the conditions on the coastal plain. Given that many plateau animals have survived a stay on the coastal plain over decades, it may initially seem surprising that herders rate the risk of mal-adaptation high enough to impede a move. But this reasoning can be explained firstly by a lack of information, since discussions on the conditions for staying on the coastal plain seldom seem to take place outside the circle of the core family. Secondly, especially in Andremba, this argument might be offered in place of real hidden motives, such as the lack of a guest right on the coastal plain.

GUEST RIGHTS AND THE WEAKENING OF UNCONDITIONAL HOSPITALITY. While herders on traditional transhumance move into a situation of fodder abundance on the plateau, on inverse transhumance to the coastal plain the cattle are fed mainly on the relatively scarce *samata* that often has to be bought. Thus, unlike other cases of seasonal migration (Fernandez-Gimenez and Le Febre 2006), inverse transhumance does not predominantly ease fodder scarcity, but leads to significantly higher fodder costs.

Besides buying most part of the fodder needed, guest herders on the coastal plain are allowed to take community *samata* free of charge. At the same time, inner-village conflicts on the distribution of *samata* are ongoing and guest herders in general have a bad reputation for selfishly overusing the *samata* trees. So, why do the villagers continue to provide guest herders with free access? First, the traditional Tanalana-Mahafaly society shares a social value and mental model of unconditional hospitality towards all guests, irrespective of whether they are kinsmen or not. This resembles the broader concept of *fihavanana* or nationwide solidarity (Kneitz 2014). However, the differing statements about not welcoming unknown herders from the plateau show that unconditional hospitality is today no longer part of all people's mental models. Second, the villagers often complained in interviews about the guest herders' use of community *samata*, but did not normally bring this topic to the community meetings. This may be because complaining in public disrupts the social value of harmony, as also observed in other regions of Madagascar (Fritz-Vietta et al. 2009, Hauge 2010). Third, if the guest herders come from the traditional transhumance areas on the plateau, many inhabitants of the coastal plain perceive a duty to reciprocate by receiving and providing the herders with free fodder.

Denying plateau herders without *longo* (relatives, friends) a stay on the coastal plain best illustrates the weakening of unconditional hospitality. The reason cited for the denial – fear of being robbed by unfamiliar guests – can also be attributed to the described perceived social change with deteriorating levels of trust and social cohesion. This change in the social environment has led to a modification of the traditionally shared mental models of 'the people love each other' and 'we are all one kin'. As described for other parts of Madagascar (Fauroux 1997, Ferraro 2002, Marcus 2008), the local unconditional hospitality shifts towards a narrower concept of kin including only people of the same descendancy (Bloch 1968, Keller 2009). From other pastoral societies around the world, social constraints on pastoral mobility and emerging conflicts are also known to be caused by narrowing or lacking solidarity and reciprocity (Finke 2000, Thébaud and Batterbury 2001, Beyene 2009).

VARIABILITIES IN MENTAL MODELS. As shown by the statements from the different interviewees, mental models of mobility, security, guest rights and kinship vary strongly and are often contradictory. On the one hand, many interviewees from both the

plateau and the coastal plain viewed the stay on the coastal plain as restricted to the existence of *longo*. On the other hand, interviewees from both regions also negated this restriction. These contradicting mental models lead to a high variation in the herders' individual decisions: those with a mental model of formal kinship dominated by clans and lineages (*raza*) would never consider moving to a place where they have no *raza* people to stay with. Others move on the assumption of 'we are all one kin' regardless of different raza, or claim an informal guest right of all people, or at least the 'known' ones. This variety is due to a highly informal institutional setting. For herders with consistent entries in their 'passport', there are no formal institutions that directly frame the move, for example, local community rules (*dina*) or clear ancestors' rules (*lilyn-draza*). Explicit social norms or ancestors' customs (*fomban-draza*) that can help to form the individual's mental model of mobility are also very limited. It is only the knowledge about traditional transhumance that serves as a kind of template.

However, regardless of the different interpretations of the conditions for guest rights, most plateau herders base their decision about whether and where to move to on the existence of *longo*. This shows that they have a good knowledge of the fact that the villagers from the coastal plain are increasingly suspicious towards all unknown guests. But many plateau herders also expressed a great fear of being a victim themselves. Yet their risk assessment does not reflect the reality of the comparatively secure coastal plain where raids are rare. Instead, their mental model of the coastal plain seems to be a reflection of the insecure situation at home on the plateau.

DIFFERENT DEGREES OF INSTITUTIONALIZATION. According to the literature on traditional transhumance, the guest rights for staying on the plateau are founded on royal agreements between the three former Mahafaly kingdoms (Battistini 1964), bonds of blood brotherhood (*ziva*) by Tanalana clan founders and Mahafaly people (Esoavelomandroso 1989), or, in the case of Andremba, familiar bonds (Armandine 1991). These agreements and bonds seem to have lost their practical relevance, as interviewees did not refer to them in the context of transhumance, and many guest herders staying in Andremba have de facto no relatives there. However, an unconditional, general guest right allowing all coastal herders to stay on the plateau was not questioned by either coastal or plateau interviewees. Most interviewees did not even think that being allowed to stay on the plateau needed justification. The only related argumentation is that transhumance to the plateau is the people's *fomban-draza* (ancestral tradition/custom). Traditional transhumance can thus be seen as a highly institutionalized practice. Whereas in the beginning it needed formal institutionalization by royal agreements or social bonds, today it is informally institutionalized through a shared mental model about the legitimate actions and roles of the involved actors (Berger and Luckmann 1966): Both the people from the coastal plain as well as the plateau consider traditional transhumance as a *fomban-draza*, and thus it is, together with *fomba gasy* (Malagasy custom), per definition the right thing to do (Evers 2006).

In contrast, inverse transhumance is still much less formally or informally institutionalized. There are several reasons for this: First, although the interviews reveal the simplicity of creating a 'new *fomba*', inverse transhumance has apparently not reached this institutionalized status. In other words, it still lacks the necessary period of continued existence for being perceived as morally just (Hodgson 1998). Second, as the social norm of unconditional hospitality and the mental model of broad kinship are no longer shared by all people, the potential for informal institutionalization is also limited. Third, inverse transhumance is realized and perceived as a kind of private affair. Unlike traditional transhumance, no collective action for formal institutionalization has taken place, for example by sincerity oath rituals (*titike*) between guest groups and the host communities. Thus, every guest herder has to institutionalize his personal stay in each host village by performing his own ritual.

CONCLUSION

This case study investigated the development of a new transhumance movement in the Mahafaly Plateau region in relation to the local socio-institutional context of formal and informal institutions, especially traditions and mental models about guest rights and kinship. The new movement in the inverse direction to the traditional transhumance movement turns out to be the main strategy for mitigating against worsening cattle raids. It is enabled and facilitated by herding families' decision-making freedom, traditional mechanisms of trust creation, and a shared concept of hospitality. Access to ancestral land (*tanin-draza*), and thus fodder and water, is found to be not a major constraint on pastoral mobility in this region. Limits to the movement arise from a change in the social environment mainly attributed to the cattle raids: The mental models of unconditional hospitality, good relations and broad kinship (*filongoa, fihavanana*) are increasingly replaced by much narrower conceptions of kinship and a kind of hospitality based on reciprocity. Therefore, many herders feel restricted in their decisions about where to move on transhumance, or if to move at all. Unlike the traditional transhumance movement, trust between moving herders and the communities at their destinations is a crucial precondition for deciding to move. Guest rights for moving herders are increasingly bound to the existence of *longo*-kin (relatives or friends) at the destination.

The present study demonstrates that individuals' adaptive capacity may differ considerably within the same social community. Adaptation options may depend on the individuals' mental models in the sense of the interpretation of the problem, the environment, and especially the society in which they live. In the case of the new transhumance movement, personal mental models enable adaptive action by some herders, while internally constraining others to undertake the same action. The range of diverse and sometimes contradictory mental models may be especially broad in the context of ongoing social change as presented here. Further research on adaptation should consider not only the framework of formal social institutions, but should also acknowledge the importance of underlying mental models.

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SUPPLEMENTARY MATERIAL.

AVAILABLE ONLINE ONLY.

TABLE S1. Time frames and number of interviewees indicating the start of cattle raiding as a problem and the start of inverse transhumance.

ARTICLE http://dx.doi.org/10.4314/mcd.v11i1.7

A review of the *Pteropus rufus* (É. Geoffroy, 1803) colonies within the Tolagnaro region of southeast Madagascar – an assessment of neoteric threats and conservation condition

Sam Hyde Roberts[I], Mark D. Jacobs[I], Ryan M. Clark[I], Charlotte M. Daly[II], Longosoa H. Tsimijaly[III], Retsiraiky J. Rossizela[III], Samuel T. Prettyman[I]

Correspondence:
Sam Hyde Roberts
SEED Madagascar, Studio 7, 1A Beethoven Street,
London W10 4LG, United Kingdom
Email: samhyderoberts@gmail.com

ABSTRACT

We surveyed 10 *Pteropus rufus* roost sites within the southeastern Anosy Region of Madagascar to provide an update on the areas' known flying fox population and its conservation status. We report on two new colonies from Manambaro and Mandena and provide an account of the colonies first reported and last assessed in 2006. Currently only a solitary roost site receives any formal protection (Berenty) whereas further two colonies rely solely on taboo '*fady*' for their security. We found that only two colonies now support an increased number of bats compared with a decade ago, whilst a further two colonies have been either displaced or disturbed and could no longer be found. A single colony appears to have declined significantly whereas a further three colonies appear to have remained static. In light of a decree that has imposed a specific hunting season for fruit bats, we hope that this census can provide a baseline for future population monitoring and contribute towards the assessment of the effectiveness of the legislation.

RÉSUMÉ

Nous avons suivi 10 dortoirs de renards volants *Pteropus rufus* dans la région Anosy au sud-est de Madagascar afin de réaliser une mise à jour de l'état de conservation et d'estimer la population de ces chauves-souris dans la région. Notre étude a montré que la densité des colonies dans la région environnante de Tolagnaro était similaire à celle des autres régions du pays. Nous dressons l'état de nos connaissances portant sur deux colonies situées à Manambaro et à Mandela en comparant nos données récentes avec celles de 2006. Un seul dortoir isolé reçoit actuellement une forme de protection formelle, Berenty, et deux autres colonies seulement reçoivent une forme de protection sous la forme de tabous locaux ou « *fady* ». Nos résultats ont montré que seules deux colonies ont vu leurs effectifs augmenter au cours de la dernière décennie en même temps que deux autres colonies n'ont pas pu être relocalisées, soit parce qu'elles ont disparues, soit parce qu'elles se sont déplacées suite à des dérangements. Les effectifs d'une seule colonie semblent avoir diminué de manière significative tandis que ceux de trois autres colonies semblent avoir été maintenus à leur niveau. Notre étude a montré que l'abondance globale de *P. rufus* dans la région n'a augmenté que d'un pourcent depuis 2006 et que cette augmentation était le résultat de la protection garantie au dortoir dans la réserve privée de Berenty. À la lumière d'un décret qui a imposé une période de chasse spécifique pour les chauves-souris frugivores, nous espérons que ce recensement pourra servir de référence aux futurs programmes de suivi de la population et contribuer à une évaluation de l'efficacité de la législation.

INTRODUCTION

The endemic Madagascan flying fox (*Pteropus rufus*) is primarily distributed around the country's periphery, with roosts predominantly found in lowland areas within 100km of the coast (Mackinnon et al. 2003, Simmons 2005, Racey et al. 2010). The highest density of roost sites appear to be concentrated in coastal locations (Andriafidison et al. 2008) with only a handful of roosts reported from the central highlands (Mackinnon et al. 2003). In 1999 and 2000 an extensive survey of around a third of the island found only a small number of roost sites within the boundaries of the Anosy Region (Mackinnon et al. 2003). In 2005 a more specific and thorough regional study reported additional *P. rufus* roosts at a further seven localities, bringing the number of known roosts in the region to nine, with a recorded total population of 1,873 individuals (upper estimate) (Jenkins et al. 2007a). The identified roosts were spread throughout the coastal lowlands of the southeast, an area spanning approximately 175km and stretching between Marovony in the north and Berenty Private Reserve to the south.

In 2000 an extrapolation based on the survey data obtained across about a third of the island estimated that the national population consisted of approximately 300,000 individuals, and issued the caveat that an estimated 30% of the population had

I SEED Madagascar, Studio 7, 1A Beethoven Street, London W10 4LG, United Kingdom
II Chester Zoo, Upton-by-Chester, Chester CH2 1LH, United Kingdom
III ONG Azafady, Villa Rabemanda, Ambinanikely, BP 318, Tolagnaro 614 (Fort Dauphin), Madagascar
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been lost over a period of just 20 years (Mackinnon et al. 2003, Andriafidison et al. 2008). The cause of this rapid decline has been well documented (Mackinnon et al. 2003, Andriafidison et al. 2008, Jenkins and Racey 2008) and attributed primarily to a combination of increased hunting pressure and the continual loss of suitable roosting habitat. The chronic degree to which the species is both hunted for bush meat, and persecuted in defense of economically valuable fruit trees (Jenkins and Racey 2008) has also prompted predictions of future declines (Mackinnon et al. 2003, Andriafidison et al. 2008). Unfortunately this pattern of decline is also observable in the other two endemic mega-chiropteran species; the Madagascar straw-coloured fruit bat (*Eidolon dupreanum*) and the Madagascan rousette (*Rousettus madagascariensis*), as well as other pteropodid species on western Indian Ocean islands (Nyhagen et al. 2005, Andriafidison et al. 2008, Jenkins and Tatayah 2009, Andrianaivoarivelo et al. 2011).

Forest cover in the Anosy Region appears to have been in a constant state of decline since the first aerial photographs were taken in the early 1950s (Vincelette et al. 2007, Temple et al. 2012). It has been estimated that as much as 90% of Madagascar's original southern littoral forest has already been lost (Consiglio et al. 2006), with a total of 26,563 ha removed from the Anosy Region alone between 1972 and 2002 (Vincelette et al. 2007). This rapid loss of forest habitat, principally the result of slash and burn agricultural practice (*tavy*), has severely damaged lowland forest formations (Vincelette et al. 2007) and the pattern continues to this day. Both roosting and foraging sites are hugely threatened by this loss of native forest, a situation exacerbated by the tendency for *Pteropus rufus* to use small, vulnerable forest remnants outside of protected areas (Jenkins et al. 2007b, Racey et al. 2010). Qualifying the danger from habitat loss alone faced by this species in our specific region of study, a further 80% of the remaining littoral forests of the Anosy Region are now subject to proposed clearance over the next 50 years, as a result of mining activity and predicted resource use (Temple et al. 2012).

With an ever-increasing body of evidence attesting to the ecological value of *Pteropus rufus* both as an important pollinator and seed disperser amid highly fragmented landscapes (Bollen and Elsacker. 2002, Mackinnon et al. 2003, Bollen et al. 2004a,b, Nyhagen et al. 2004, Jones et al. 2009, Racey et al. 2010, Shilton et al. 2015), its conservation should now be considered a priority for areas in urgent need of forest regeneration. Further evidence to support the conservation of flying fox roosts, and to encourage the conservation of large colonies stems from the finding that the ecological function attributed to large pteropodid bats, notably seed dispersal, may decline once a population has been reduced to below a threshold size (McConkey and Drake 2006). It is therefore apparent that not only are these keystone species most effective when they are in abundance, but also that their abundance must be monitored and safeguarded.

A decade has now passed since the last comprehensive census of *Pteropus rufus* was carried out in the southeast Anosy Region (Jenkins et al. 2007a) and since then the legislation governing game animals has been updated (Décret N. 2006-400, Durbin 2007, Racey et al. 2010) in an attempt to reduce hunting pressure and curb declines. These laws now provide bats with some protection in the form of a closed hunting season (2 September–30 April), yet are largely ignored as a result of a widespread lack of recognition and enforcement, rendering them effectively impotent (Jenkins and Racey 2008, Rahaingodrahety et al. 2008). Hunting has played a significant role in recent Madagascan fruit bat declines, with both the proliferation of firearms and erosion of localised taboo or *fady* cited as responsible factors (Mackinnon et al. 2003, Jenkins and Racey 2008, Jones et al. 2008, Andrianaivoarivelo et al. 2011). Large pteropodid bats are extensively hunted in Madagascar, principally for bushmeat and to protect economically valuable cultivated fruits from predation (Jenkins and Racey 2008). Bats are considered an important source of nutrition, particularly in remote and rural communities, however growing evidence suggests that unsustainable and exploitative practices are becoming more widespread to the evident detriment of multiple species (Andriafidison et al. 2008, Andrianaivoarivelo et al. 2011).

Our study aims to report on the condition of all the known colonies in the southeastern Anosy Region, and provide an update on their local conservation status, and to highlight any persisting or developing threats. During the time of the region's previous population census, flying foxes were considered *animaux nuisibles*, i.e., pests with hunting permitted without restriction (Mackinnon et al. 2003), and only local *fady* and cultural sensitivities providing any protection (Jones et al. 2008). Our objective was to observe what impact the 2007 law has had in the area if any, and to reassess the condition of the known flying fox colonies in the southeastern Anosy Region.

METHODS

Between the months of July and October 2015 a total of 10 roost sites were identified within the borders of the Anosy Region (Figure 1). The roosts were then visited and surveyed by a small team of Malagasy and international researchers. The precise location of each colony was obtained through a combination of local community knowledge and previously cited GPS coordinates (Bollen and Elsacker 2002, Jenkins et al. 2007a, Rahaingodrahety et al. 2008). The survey period was initiated once the breeding season had been concluded (April–June) in order to minimize disturbance, but did however overlap partially with the national open hunting season (Durbin 2007). Our monitoring team consisted of a minimum of two individuals and a maximum of six, including translators. To provide continuity and consistency within the count data, a single researcher (SHR) was present at each survey and responsible for the final count determination.

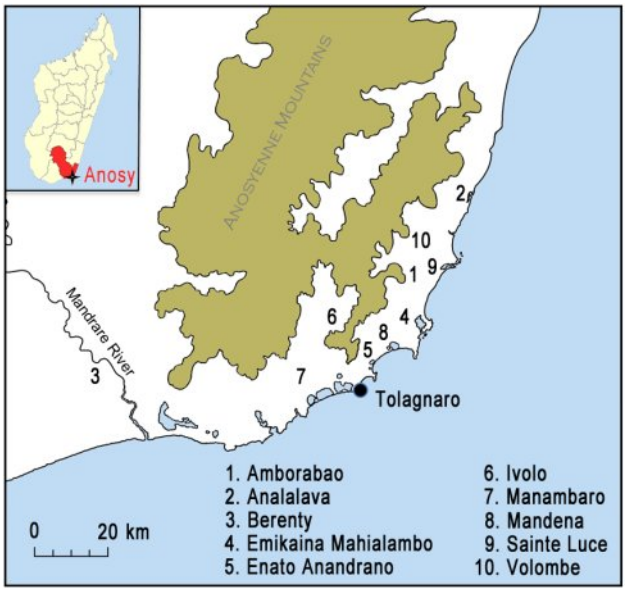

Figure 1. Relative locations of each of the 10 Pteropus rufus roost sites assessed during the study, and their greater position with regards to the island of Madagascar.

Roost sites were visited in the communes of Amborabao, Analalava, Berenty, Emikaina Mahialambo, Enato Anandrano, Ivolo, Manambaro, Mandena, Sainte Luce and Volombe (Figure 1). On each occasion our visit to the roost was accompanied by either the designated head of the village (*chef de fokontany*), the local president of VOI (VOI – body responsible for community level resource management) or the president of FIMPIA (a higher tier assembly made up of VOI presidents). During occasions where the roost was situated in sacred forest or in cemetery, permissions were always obtained and the landowner was often hired as our guide. A further roost site previously reported to exist in Marovony (Bollen and Elsacker 2002, Jenkins et al. 2007a) was deemed to be outside of the Anosy Region border and given the lack of detail regarding its location, was not visited. Roost counts and inferred colony size was achieved by counting the individual bats roosting in trees, with roost trees being carefully scanned using binoculars from a suitable vantage point. All surveys were conducted during the daytime, when all bats were expected to be present at the roost. Wherever possible estimates made by several independent observers were obtained and the highest confirmed figure was recorded to guard against accidental underscoring. In addition, wide-angle photographs were taken at all roost sites, and scrutiny of the enlarged images was undertaken to review our results at the site. Similarly, it was often the case that during our assessments, some form of external disturbance caused the colony to take flight and travel to a secondary roost site as a single group. This allowed us to observe the colony in the air, and to film and analyze the footage accurately using basic video tools (Final Cut Pro X).

RESULTS

Our study indicates that the total abundance of *Pteropus rufus* in the southeastern Anosy Region stands at approximately 3700 individuals, using conservative estimates collected across the 10 colonies. At first glance this number appears to have risen significantly from the 1873 individuals recorded in 2006 (Jenkins et al. 2007a), but important caveats must be considered. Firstly this study includes count data from three additional roost sites, Manambaro, Mandena and Berenty Private Reserve, which were not included in the initial 2006 census that we are using as a baseline. This is either because the roosts were not established (Mandena), because their existence was unknown to the researchers (Manambaro) or due to a lack of quantitative data available at that time (Berenty). The combined abundance of these three additional roosts is 2755 bats, substantially more than was previously recorded for the area. Conversely, the total abundance does not include contributions from two roost sites (Enato Ananadrano and Emikaina Mahialambo), as these colonies could no longer be found, and are likely to have either relocated or dispersed. The total number of bats lost from these roosts is not clear, as no historic datasets are available for the colony at Enato Anandrano. However the roost at Emikaina Mahialambo was thought to consist of some 100 bats (Jenkins et al. 2007a).

Of the ten colonies surveyed in this study (Table 1), only two were found to contain over 500 individual bats, (Berenty and Ivolo) and of the extant colonies three were found to support fewer than 200 individuals (Analalava, Sainte Luce and Volombe). The colony present at Berenty Private Reserve is by far the largest colony in the region and supported 2160 bats at the time of its last census in 2013 (J. P. Seccaldu, October 2015, pers. comm.). The colony appears to have increased by approximately 360 individuals between the previous two censuses, conducted in 2011 and 2013 and is known to have stood at between 800 and 1000 individuals in 2001 (Bollen and Elsacker 2002). It is likely that this colony has experienced further growth over the subsequent years. This is the only strictly protected bat colony in the region, and similar increases have not been reflected elsewhere over the same period.

The only other colony in the study besides Berenty to have shown an increased number of bats when compared to the previous count, exceeding the margin for error in estimation, was at the roost situated in Sainte Luce. This colony supported just 104 bats when surveyed in 2006 and now supports approximately 130

Table 1. GPS position (latitude/longitude) of roost sites. (Habitat extents were mapped using a handheld Garmin 62sc device and determined using Google Earth Pro.; Information regarding the present flying fox populations in Berenty Private Reserve was ascertained through personal communication with long-term forest guide Jean Philipe Seccaldu)

Location	Survey date	Population estimate	Habitat extent (ha)	Forest type	Roost protection	Major threat	GPS
Amborabao	09/22/2015	338 ± 15	4.38	Sacred forest	Yes	Disturbance	E047°01'55.81", S24°49'03.58"
Analalava	09/30/2015	140 ± 25	21	Littoral forest	No	Deforestation	E047°13'58.49", S24°37'00.53"
Berenty Private Reserve	07/06/2015	2165	177	Private reserve	Yes	None	E046°18'25.97", S25°00'33.30"
Emikaina Mahialambo	10/04/2015	0	0.3	Eucalyptus plantation	-	-	E047°03'49.75", S24°53'55.50"
Enato Anandrano	09/22/2015	0	2.68	Sacred forest	-	-	E046°59'35.66", S24°55'04.69"
Ivolo	10/03/2015	560 ± 10	8.36	Eucalyptus plantation	No	Logging	E046°55'05.09", S24°55'35.33"
Manambaro	10/13/2015	290 ± 20	155	Niaouli stand	No	Logging	E046°50'57.23", S25°00'51.86"
Mandena	10/12/2015	300 ± 20	85.1	Niaouli stand	Yes	Mining activity	E047°01'37.70", S24°58'04.31"
Sainte Luce	10/07/2015	130 ± 5	382	Littoral forest	No	Deforestation	E047°08'26.16", S24°48'41.92"
Volombe	10/11/2015	60 ± 5	1.88	Sacred forest	Yes	Disturbance	E047°05'37.07", S24°41'16.19"

bats, representing a positive difference of some 25%. Elsewhere two of the surveyed colonies have shown no significant change when compared to the data available from a decade ago (Analalava and Volombe), with both roosts supporting a very similar number of bats as in 2006. Finally, alongside the two colonies that could no longer be located (Emikaina Mahialambo and Enato Anandrano), a large negative difference can be seen in the number of bats observed now at Amborabao (338), compared with the number of individuals in 2006 (412), a reduction of 18%.

The large colony observed at Ivolo represents a significant proportion of the flying foxes in the region, yet the true extent of the colonies size here remains unverified. Although we observed a large group of approximately 560 bats, the local *chef de fokontany* explained that this was merely half of the full colony. The previous estimate presented in Jenkins et al. (2007) also suggests that two groups are present here, and that the combined total in 2006 was circa 1000 bats. However we could gather no further evidence to support the presence of a second large group of bats over the course of our several hour roost visit. It is possible however that a secondary roost does exist out of sight in this mountainous region, although we did not make a single aerial observation to indicate the presence of a nearby secondary roost or recently disturbed group.

The average colony size for the region stands at 498 bats per roost, notably higher than the national average of 400 (Mackinnon et al. 2003). However it is clear that the colony at Berenty influences this result due to its relatively large size, and if excluded the average colony size drops to just 259 bats per roost. Given the lack of directly comparable data between our study and the data available from 2006, only an approximate indication of general trend can be extracted. Of the ten colonies identified in this study and the nine assessed in 2006, only four of the roosts are suitable for direct comparisons (Amborabao, Analalava, Sainte Luce and Volombe). Earlier datasets are available for the Berenty colony dating from between 1996 and 1999 (Long and Racey 2007).

When assessed together, the relatively small and unprotected roosts appear to now support 8% fewer bats than a decade ago whereas the data available for Berenty suggests that this colony supported some 8.25% more bats in 2013 than it did in 1999 (Long and Racey 2007). Assuming that this increase has been linear, based on the relatively stable conditions at the roost, we estimate the colony at Berenty to have supported approximately 2070 in 2006. Once this inferred Berenty data are also figured into the calculation, the overall abundance of bats in our study area can be seen to have increased by 1.25% between 2005/6 and 2015/6. This calculation is based using the upper abundance estimates offered in Jenkins et al. (2007) and Long and Racey (2007). The modern figures are based solely on the number of bats observed during our assessment, and do not include population estimates based on community opinion.

The remaining five colonies were excluded from comparison as four of the roosts; Emikaina Mahialambo, Enato Anandrano, Manambaro and Mandena lacked the requisite datasets. In the case of the Ivolo colony, the large unknown error margin in abundance made it inappropriate for comparisons to be drawn. However it is important and perhaps just as useful to consider the health and status of each colony individually as each colony is subject to a specific set of circumstances. Also given the difficulties associated with comparing and making generalizations regarding the total population present in the southeastern Anosy Region, further information pertaining to each colony's individual status is presented in the following. Further details of the communities' attitude towards local roosts and our survey methods and techniques at each site are also included.

AMBORABAO (FARAFARA–VATEMBY). The well-known colony exists in a very small (<5 ha) remnant of humid forest (altitude 148m), and our survey counted 338 bats. Local *fady* protects the forest patch, as it is the sacred site of an ancestral tomb. Despite this the colony has declined over the past ten years. Previous counts indicated that some 412 bats once occupied this roost (Jenkins et al. 2007a), however the small size of the forest fragment and lack of suitable roosting branches may be restricting the colony. Our SEED Madagascar (local NGO) community agent and local *chef de fokontany* suggest that the population is currently increasing indicating that bat numbers declined since the 2006 count. The primary roost itself is spread across several levels and multiple trees including *voapaky* (*Uapaca* spp. Euphorbiaceae), *fotsivavo* (unidentified species, Annonaceae) and *tavolo* (*Cryptocarya acuminata* Lauraceae). Average canopy height is around 15m in the fragment interior. Hunting is known to take place at feeding sites, particularly during the lychee season. Damage to the patagia of many bats was observed, which could be the result of slingshot. The bats are respected to an extent and do infrequently bring in income to the remote community as passing tourists can pay to visit the roost, however they are also viewed as pests which maraud fruit trees. Disturbance is a major threat to this colony (Figure 2), as the roost is surrounded by agricultural land, and situated near a busy community pathway. Regular disturbance causes the entire colony to take flight to another forest fragment some 700m southwest and our survey coincided with such an event, allowing for a straightforward and accurate census.

ANALALAVA (ANTRANOPANIHY). This unprotected parcel of littoral forest is relatively isolated, situated on a small island cut off by the arms of an estuary (Asihanaky), making it accessible only by pirogue. The forest and roost are ca. 3.6km from the nearest village, Ambanihazo and at an altitude of just 15m. Our colony

Figure 2. Roosting and disturbed Madagascan flying foxes (*Pteropus rufus*) at the Amborabao colony, assessed during this study (September 2015). Photographic credits: M. Darling and S. Long.

count of 140 individuals is similar to that previously made in 2006, of 150 bats. Our local FIMPIA representative and guide disclosed that hunting for bushmeat is common in the area and that bats are also killed to protect valuable fruit crops. Again during our surveys we observed bats with damage to their patagia, and again we were told that slingshots are the most common form of hunting, with guns now rare. Despite this the roost itself is protected by FIMPIA, meaning that hunting of bats occurs away from the roost. We were informed that the population at this site was once very large and supported over 1000 bats, but due to excessive and unsustainable hunting numbers have been greatly diminished.

During our survey visit we found evidence that both logging and *tavy* is practiced close to the roost site, and trees had been felled just several meters away from the main roost trees. Evidence from recent and extensive fires demarcated the forest boundary, and the interior is highly degraded secondary forest. The roost itself exists at two proximal locations within the same forest, and we were able to conduct the count as the bats moved between the two sites just prior to dusk. The average forest canopy height is around 15m and notable roosting trees include both *fatsikahitra* (*Canephora madagascariensis* Rubiaceae) and *voatsimatra* (*Salacia madagascariensis* Celastraceae).

BERENTY PRIVATE RESERVE. The bat population at Berenty Private Reserve is the largest known in the region, with a total of 2160 reported from the last census conducted in 2013. The population here is spread over five closely adjoined roosting sites, all centered on and around mature tamarind (*Tamarindus indica* Fabaceae) trees, with nearby acacia (*Acacia rovumae* Fabaceae) and fig trees (*Ficus* spp. Moraceae) providing additional roosting capacity. All roosting sites within the gallery forest reserve are strictly protected from both hunting and disturbance, with tourists also being prohibited from approaching within 70m. However it is known that hunting does still occur at feeding sites outside of the reserve (J. P. Seccaldu, pers. comm., October 2015). The colony has expanded rapidly since the 2011 count when it consisted of approximately 1800 individuals. Previously hunting for bushmeat was known to occur outside of the reserve at the bat feeding grounds, however this also seems to have been curtailed as of 2010 as a result of education and pressure from the reserve management.

EMIKAINA MAHIALAMBO (EKAIMBE). We were unable to locate this colony of flying foxes during our study and we believe that the population has relocated, merged with a nearby colony or has been extirpated. Jenkins et al. (2007) reported that the colony consisted of around 100 bats and these were at the time subject to hunting with guns. At the time of our visit, the eucalyptus plantation (a mixture of *Corymbia citriodora* Myrtaceae, *Eucalyptus camaldulensis* and *E. robusta* Myrtaceae) had been cut down and no evidence of a roost remained. Local community members and the *chef de fokontany* of Mahialamba and chef of FIMPIA both suggested an alternative site (E047° 3'49. 75", S24°53' 55. 50") where bats had been seen roosting more recently, however this small and exposed eucalyptus plantation had also been abandoned. The colony had last been observed there in May 2015, and was estimated to have consisted of around 80 bats. However the barren landscape had been subjected to large fires and a severe windy period in September 2015. The site was also unprotected and the plantation open for unrestricted resource use, although the area is not particularly accessible with the nearest village (Mandromoromotra) almost 5km away.

ENATO ANANDRANO. As with the previous roost, we were unable to locate this colony. Satellite imagery obtained from Google Earth (2012) revealed that the lowland rainforest location, reported by Bollen and Elsacker (2002) and cited by Jenkins et al. (2007), had since been completely cleared. We were further informed by members of the local community that the bat roost had subsequently moved to a small sacred forest stand, just 550m from the village up until 2010. During this time the bats had been protected by *fady* although the high level of disturbance would have made this location difficult for the bats in the long-term. A combination of agricultural encroachment, human disturbance, persecution at feeding sites and less than three hectares of forest is likely to have forced the colony to either relocate or disperse. The abandoned roost tree was confirmed as *haramy*, a vernacular name we could not associate with a Latin binomial. Community members insist that bats still forage in the village at night on *Ficus* spp. indicating that a roost may still be present in the foothills of Enato Anandrano. The landowner, whose site protected the bat roost until 2010, estimated that the colony contained around 300 bats before leaving the area.

IVOLO. The Ivolo colony is thought to consist of two large groups of flying foxes roosting in a privately owned and regulated mature eucalyptus (*Corymbia citriodora*) plantation. The plantation is approximately 50 years old and on reaching maturity is now subject to intensive logging and reclamation. Our colony count of approximately 560 individuals was carried out with a clear line of sight and therefore a high degree of accuracy. However the *chef de fokontany* of Ivolo informed us that an hour before our arrival, a man armed with a small firearm had attempted to poach bats, and in the process had disturbed one large group. We were informed that the group that had been disturbed was equal to the size of the group that remained. If true, the total population would be around 1120 – similar to that reported in 2007 (Jenkins et al. 2007a). However, we can only confirm the presence of 560 bats with any certainty.

The bats here are afforded no protection, and the logging is indiscriminate of roost, with trees being felled close to the roost trees. Similarly, poaching seems to occur at the roost site, and we were informed that hunting both for meat and pest control is common. Whilst hunting bats at their roost site is considered illegal here, the law is not enforced, and away from the roost site legal hunting involves netting at fruiting lychee and mango trees. As the plantation covers approximately 10 hectares, with all the eucalypts of equal age and height (20–22m), the colony seem to be able to settle anywhere within its boundaries. There is also a small sacred forest area near the village that is also frequented by the bats, where protection is afforded through taboo (*fady*). With the disturbed bats elsewhere for several hours during our survey, there may also be another roost site at higher altitude in the mountain foothills.

MANAMBARO. A large stand of fast growing and non-native niaouli (*Melaleuca quinquenervia* and *M. leucadendra* Myrtaceae) trees ca. 12km outside of Fort Dauphin (Tolagnaro) supports a colony of around 285–300 bats. This roost site has never been reported to the best of our knowledge yet is thought to have been

established at this location for the past 20 years. The plantation covers ca. 155 hectares and supports the local communities of Magnavara and Nosy Be, being used primarily for firewood, charcoal and brick manufacture. The colony here is extremely sensitive and we were informed that this population is commonly hunted for bushmeat, with slingshot being the principal hunting technique. The swampy nature of the area offers a modicum of protection for the roost, but busy rice paddies surround the plantation margins. Large declines are thought to have occurred over the past two decades and the roosts close proximity of the roost to Fort Dauphin and the good transport infrastructure make the roost more vulnerable. The bats use the emergent trees to roost, which stand at approximately 12m, two meters above the majority of the monoculture. This allowed for a relatively straightforward visual census from a medium distance, although some bats may have been obscured.

MANDENA. A newly formed roost on the southern outskirts of the QMM / RioTinto mining site, is thought to have been established within the past two years. The introduced species of niaouli stand covers approximately 100 hectares of riverine and swamp habitat in the area. The roost is protected by its inaccessible location and the restricted public access offered by the mine. The canopy height here is around 10m on average, with bats favoring emergent trees of around 12m in which to roost. Our survey was made from a boat positioned in the estuary, and we were able to observe what seemed to be the entire colony fly over the water body to a secondary roost site, and then back. The flight was filmed and analysed using Final Cut Pro to obtain an accurate count although we could not be certain that the entire colony took flight.

SAINTE LUCE. This roost is currently situated in the forest fragment S6 but has previously been cited as existing in S7 (see Figure 1 in Lowry et al. 2008), a twin fragment laying parallel and only separated by a thin ribbon of swamp. Together these two forest fragments make up approximately 382 hectares of original littoral forest, making them one of the largest remaining patches of this lowland forest habitat in existence. This roost was first reported in 1992 by Lewis Environmental Consultants, as part of the QIT Madagascar Minerals Project (Lewis Environmental Consultants 1992) who reported a large colony of some 300 individual bats. Repeat visits to the roost and multiple counts over the course of 2015 enabled us to make a confident estimate of the colonies current size, at around 130 individuals. It is apparent that this roost was once considerably larger, with Bollen and Elsacker (2002) reporting between 300 and 350 bats still in 2000 but Jenkins et al. (2007) reported just 104 bats in 2006. The forest here is currently open to unrestricted community resource use and vulnerable to outside exploitation. Further, it is experiencing a high level of degradation and the roost sites are threatened by logging. However the NGO SEED Madagascar is currently engaged in a community project aiming to safeguard the colony and hopes to secure its long-term presence in the area.

The colony is known to occupy two roost sites in S6, and currently none are known from within S7. All previously cited coordinates in S7 were investigated but no further evidence of bat occupancy was found, only evidence of extensive logging. Given the similarity between the colony size previously reported in S7 in 2002, we infer that the population is likely to have simply changed locations and now resides in S6. The primary roost site now consists of a small cluster of tall *hazomainty* (*Diospyros* spp. Ebenaceae) trees (approximately 25–26m), with branched evergreen crowns. Other trees frequently used as part of the secondary roost include *hazondroka* (unknown vernacular name), *nato* (unknown spp. Sapotaceae) and *fantsikaidroka* (*Pseudopeponidium asosa* Rubiaceae). The bats in this population are extremely sensitive and wary of humans, and several individuals were seen with observable damage to their patagia. Evidence of logging is clear at both roost sites and the colony is threatened by continual logging. Similarly, low-level tourism occurs at this roost site, with a nearby eco-lodge offering its cliental the opportunity to visit the roost, as well as monthly visits made by researchers and volunteers from local NGO SEED Madagascar.

VOLOMBE. A small colony consisting of some 60–65 bats, situated in a tiny fragment of sacred forest near the remote community of Androtsy Antanadava. The colony is believed to have once been very large and has been present in the area for the past 40 years, but was recently displaced from a nearby forest (Andranopanihy) which was clear felled. The roost site is supposedly protected by *fady*, although the bats are hunted with both nets and firearms at their feeding grounds; our guide was informed that occasional hunting also occurs within the sacred forest. The landscape is dotted with small remnants of forest protected as sacred tomb sites, yet the small size of this colony suggests that consistent hunting and persecution is prevalent. The extent of the roost site is less than two hectares and encircled by agricultural plots, yet potentially viable habitat still remains on the nearby hills only a few kilometers away. The roost here is spread across multiple tree species, but most notable are *varongy* trees (*Rhus taratana* Anacardiaceae).

DISCUSSION

Given the high level of deforestation and habitat fragmentation in Madagascar (Goodman and Benstead 2003, Harper et al. 2007, Temple et al. 2012), the protection of endemic and ecologically important species should be considered amongst the highest priorities. The established capacity of this mainly frugivorous species for long distance seed dispersal, pollination and the positive effects of passage of seeds through the gut on germination (Bollen and Elsacker 2002, Racey et al. 2010, Oleksy 2012, Oleksy et al. 2015), should make it a highly desirable species in areas striving to sustain their natural environments. The highly fragmented forests of the southeast appear now to depend on the abilities of such species as the flying fox if they are ever to recover to a state where ecosystems function effectively and continue to support the high levels of species richness and biodiversity previously observed (Ganzhorn and Goodman 2007). With evidence suggesting that the ecosystem services provided by bats are significantly diminished as their populations decline (McConkey and Drake 2006), a concerted effort to safeguard the species and encourage population growth should be compelling and a cornerstone of any serious conservation strategy.

Colonies of *Pteropus rufus* can attain sizes of up to 5,000 individual bats (Mackinnon et al. 2003), which places into perspective the small magnitude and vulnerability of the majority of existing roosts in the Anosy Region. With many populations now existing at such low levels, the time necessary for small colonies to grow in size will be extensive especially given the species pro-

duces a single young annually, and only occasionally twins (Mackinnon et al. 2003). The smaller the population, the more protracted the recovery or growth will be, and the more important each individual within the colony becomes. Alongside what is known about the reproductive character of the Pteropodidae in general (Hayssen et al. 1993) a further understanding of details such as lifespan in the wild and colony sex ratio will require verification before predictions of temporal population growth can be confidently proposed. The population growth seen in the colony at Berenty Private Reserve over recent times offers cause for optimism and supports a theory that given adequate protection and respect, this species can rebound. However the Berenty colony was large to begin with, and the rapid growth is likely to be proportional to the colony's initial size.

The study area clearly still supports a significant number of bats distributed across several colonies, with colony density here appearing to now approximate the levels seen in the northwest and central west lowlands (Mackinnon et al. 2003). However this study only offers a snapshot of the colony size at a single particular time, and cannot therefore offer any insight into the fluctuations occurring over the intervening years and months. Furthermore the study only includes roosts of which we are aware of, and it is quite possible that further colonies exist further inland or at higher altitudes in the Anosyenne Mountains, where potential habitat, albeit at higher elevation still remains. It is also important to stress that our study only provides data in the form of single point counts, and past research at Berenty has shown major fluctuations in colony size seasonally (Long and Racey 2007) irrespective of hunting and disturbance. Such large-scale seasonal variation in abundance indicates that certain large roosts like Berenty may be acting as central colonies, with bats seasonally dispersing in the wet season to smaller satellite colonies, before returning in the dry season.

Presently it is unclear where these missing bats go when they leave the Berenty roost, but it is known that this species can cover large distances whilst foraging (Oleksy et al. 2015), raising the possibility that bats from Berenty join the other colonies reported in this study during the rainy season, despite the nearest roost site in the study being ca. 55km away. Similarly, other bat roosts are thought to exist to the northwest of Berenty, in the Androy Region but have never been located (Paul A. Racey, pers. comm., January 2016). This dispersal event also appears to coincide with the bats breeding season (Mackinnon et al. 2003), and may be a means of ensuring that high levels of genetic heterogeneity are preserved across the colonies. Other species of pteropodid bat elsewhere have been observed flying far greater distances so it is certainly a possibility (Epstein et al. 2009). If this were the case it could mean that *Pteropus rufus* populations are very large, and similar to *Rousettus madagascariensis* and *P. niger* in Mauritius, could extend panmictically across a regional or even national scale (Goodman et al. 2010, Larsen et al. 2014). Importantly our study was conducted at a time corresponding with a period when bat abundance is highest in Berenty (Long and Racey 2007), suggesting that the bat counts across the other roost sites are not inflated by supplementation from the Berenty colony and represent the true abundance at each colony. The large variation in colony size described by Long and Racey (2007) at Berenty emphasises the importance of timing when surveying and monitoring *P. rufus* colonies.

Our results confirm that the species maintains a high degree of roost fidelity if unmolested, with most of the colonies still present in the same or adjacent locations over a decade on. The colony at Manambaro is thought to have persisted in the same location for over 20 years (Jean Nascisse Ralaifiany, pers. comm., October 2015) whereas the colony in Sainte Luce is known to have been present in the vicinity since at least the late 1980s (Lewis Environmental Consultants 1992). This also suggests that serious threats must have been faced by the colonies at Enato Anandrano and Emikaina Mahialambo to cause their disappearance. The colony at Mahialambo was previously known to sustain losses through the use of firearms (Jenkins et al. 2007a) and any escalation could have resulted in roost abandonment. It is possible that the new roost at Mandena mine consists of bats that migrated from either or both of the lost roosts at Enato Anandrano or Emikaina Mahialambo. The short distance between the three sites (Enato–Mandena 6.5km, Emikaina–Mandena 8.6km) would have made for a relatively easy journey given the long distances the species is capable of flying (Racey et al. 2010, Oleksy et al. 2015).

The small size and lack of growth observed at the majority of the roosts assessed in this study indicates that the flying foxes in the region remain under pressure. However the fact that the average colony size remains broadly consistent with the findings of Mackinnon et al. (2003) highlights this specie's resilience being able to tolerate small forest patches near to human settlements, to use both native and introduced tree species as suitable roosts and even relocate roost site. Currently only one of the ten roost sites is afforded effective and long-lasting protection (Berenty), whilst the colony at Mandena is secure only on the grounds that it resides on private land. Fortunately the colony here exists outside of the proposed mining zone, however in decades to come once the mine is closed, the plantation will likely be in great demand. Of the remaining six extant roosts only two are quasi-protected by occupying 'sacred forests' or the sites of ancestral family forest tombs (Amborabao and Volombe). However both of these roosts are precariously enduring in tiny forest remnants, making them vulnerable to perturbation by disturbance, exploitation or loss of roosting habitat. In the case of the colony at Enato Anandrano, the sacred forest we visited where the previous roost had been abandoned, we saw clear signs of logging and severe agricultural encroachment. These same practices were also manifest at the roost sites at Amborabao and Volombe, and their long-term futures must be considered as imperiled. It is clear that *fady* has played an important role in protecting wildlife in the past, but modern pressures are slowly eroding traditionally maintained practices, and the protection taboo offers to wildlife can no longer be taken for granted.

The two roosts occupying littoral forest fragments at Analalava and Sainte Luce represent the only two colonies in the study besides Berenty to roost in natural forests. These littoral forest fragments have been substantially reduced in size and degraded over time, and now exist only as a series of disconnected remnants (Bollen and Elsacker 2002, Ganzhorn and Goodman 2007, Temple et al. 2012). The prevailing pattern of deforestation and littoral forest loss continues and significant future losses are predicted, particularly in Sainte Luce (Temple et al. 2012). The bats roosting at these fragments have easy access to a large variety of endemic food items, and a dietary study between 1999 and 2001 indirectly observed the bats at Sainte Luce feeding and dispersing

the seeds of 40 fruit species (28 genera, 21 families) (Bollen and Elsacker 2002). Similarly Racey et al. (2010) reported that the diet of this species seems highly adaptable and varies geographically, depending on locally available resources. The bats dual capacity for long distance seed dispersal and pollination is vital for ensuring the genetic heterogeneity and diversity is maintained between plant communities of different and isolated forest fragments, and vital for any future forest expansion and regeneration.

The flying fox population at Sainte Luce has clearly fluctuated over recent times, but has seemingly increased steadily since 2006. Prior to this, the colony was known to have experienced intense harvesting and stood at between 300–350 individuals in 2001 (Bollen and Elsacker 2002). The forest fragment in which the colony resides, S6 has been reduced by some 63 hectares since 2001 and is currently exposed to heavy degradation. Forest loss in Analalava are less well documented but it seems the bat population increased between 2001 and 2006, from around 50 bats to between 100 and 150 individuals, a total which our study has found is accurate still today. Currently both the Analalava and Sainte Luce colonies are under intense pressure from unregulated logging, hunting and the various aspects of anthropogenic disturbance. Although we saw multiple individuals with damage to their patagia at both roost sites, this cannot be definitively attributed to hunting practices, as it is also known to occur naturally as a result of mis-navigation and even aggressive interaction (Paul A. Racey, pers. comm., January 2016). Arguably however these two colonies represent two of the most valuable roosts observed in the study, and future conservation work should focus on their protection. Individuals from these roosts are likely to disperse the largest variety of native seeds on a regular basis, due to their natural diet and ease at which they can acquire fruits and berries. They also are more likely to move between patches of natural forest most frequently due to the position of their home roosts, meaning their dispersal of seeds could contribute significantly to the regeneration of littoral forests (Bollen and Elsacker 2002).

These two littoral forest roosts are threatened primarily by deforestation and the loss of suitable roosting habitat. The twin forest fragments S6 and S7 in Sainte Luce presently provide sufficient habitat and refuge, however recent political and forest resource use reforms now permit unregulated access and wood collection in these forest fragments and extensive logging is underway. These fragments now solely support multiple local communities and supply external timber merchants without regulation since the recent protection (Système des Aires Protégées de Madagascar status) offered to nearby fragments S8 and S9 (NAP Ambatoatsinana decree N. 2015-778). This management system needs urgent revision if the bats and local human communities are to prevail in forthcoming decades, however the bats would gain protection if they were to move to one of the newly protected sites. The Analalava colony receives slightly better protection due to the difficult access and isolated nature of the forest; however during our visit we saw evidence of extensive fire damage and logging on the forests boundaries, as slash and burn agriculture (*tavy*) encroaches nearer to the roost. With the national policy currently dedicated to tripling the area protected across Madagascar (Andriafidison et al. 2008), threatened littoral forest habitats that are known to support exceptionally high levels of biodiversity and include bat roosts should be considered strong candidates.

Elsewhere, the roost at Manambaro seems fairly secure, situated in an expanding niaouli stand spread over some 155 hectares of swampy ground. Accurate historical population data for the colony is not known to exist however local community members agree that the colony was at one time a lot larger. The proximity of this non-endemic forest to the larger human populations and the city of Tolagnaro makes it vulnerable to rapid consumption and exploitation if permissions around resource use were to change. Similarly the large private eucalyptus plantation at Ivolo is susceptible to extensive felling given any changes to management policy, particularly as the plantation has now reached maturity making the estate a valuable resource. Such economic pressures make the colonies vulnerable to displacement, yet their continued presence underlines the remarkable adaptability of *Pteropus rufus* in terms of habitat type and quality, and the degree of disturbance it can tolerate (MacKinnon et al. 2003, Jenkins et al. 2007a). Our observations have shown that across the ten roosts included in the study, 13 species of tree have been utilized as main roost sites, including three notable introduced species, *Corymbia citriodora*, *Melaleuca quinquenervia* and *Tamarindus indica*, but these account for 50% of the colonies primary roosting trees. The high proportion of introduced tree species acting as alternatives for native and endemic species, perhaps suggests a lack of suitably large and mature native trees in many areas. Our results also reinforce the importance of small forest patches and sacred forests for the persistence and preservation of flying fox colonies across a highly modified and fragmented landscape (Jenkins et al. 2007a, Andriafidison et al. 2008, Racey et al. 2010).

It is our hope that the information outlined here, alongside the previous work of Jenkins et al. (2007), can contribute towards future flying fox monitoring in the region and stimulate the establishment of long term conservation projects to protect these ecologically important species. We echo the need for community-led conservation programmes to boost the number of bats present within small and vulnerable colonies, and to work towards the long term protection of both roost and feeding sites (Jenkins et al. 2007a, Jenkins and Racey 2008, Racey et al. 2010). A nationwide strategy for improving education with regards to bat conservation is now required to halt the declines seen over recent years and to propagate knowledge of the recent 2007 law amendments. The importance of bats as a valuable source of meat should also be considered on a localized scale, with any sustainable community harvest quotas set against the background of local bat population declines and pressures from expanding human communities (Mildenstein et al. 2016). Similarly the impacts associated with increased bat numbers such as increased interference of fruit crops should be estimated, offset, and included in carefully considered conservation management schemes (Abdul Azis et al. 2016). This review will hopefully set a useful marker for future *Pteropus rufus* monitoring in the southeastern Anosy Region and provide indirect data as to the effectiveness of the 2007 hunting decree.

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SHORT NOTE

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Synthesis of the silky sifaka's distribution (*Propithecus candidus*)

Erik R. Patel

Correspondence:
Erik R. Patel
Lemur Conservation Foundation, Myakka City, FL 34251, United States
E-mail: patel.erik@gmail.com

In this paper we 1) review the population abundance and distribution of *Propithecus candidus*, 2) comment on Rabearivony et al. (2015) and Rasolofoson et al. (2007) regarding *P. candidus* elevational range, distribution, and lack of occurrence in the pet trade.

ABUNDANCE

Silky sifakas (*Propithecus candidus*) have long been recognized as one of the rarest and most unique lemurs (Mittermeier et al., 2010). Although not albinos, they are a leucistic species exhibiting more skin depigmentation with age than perhaps any other non-human primate. This may be caused by a vitiligo-like skin condition (Linder 2013 In litt.). They are one of the largest bodied lemurs and generally inhabit high montane habitats up to 1875m, higher than any other sifaka or Indriid (Patel 2014). Tragically, there are currently believed to be less than 2000 individuals remaining in a small region of northeastern Madagascar (Mittermeier et al. 2010, Patel 2014). Group encounter rates from a line-transect survey in northern Marojejy National Park (NP) in 2007 are extremely low at 0.015 groups/km² (Loudon et al. 2016). Recent density estimates from rapid surveys conducted by ERP, in Anjanaharibe-Sud Special Reserve (SR) in 2015 are also extremely low at 1.9 individuals (indiv.)/km² (north-east near Ambodisatrana) and 0.29 indiv./km² (central-east near Camp Indri), though higher in the western extension at 2.59 indiv./km² (south-west near Ampoanaomby). These density estimates are considerably lower than most other eastern sifakas such as *P. edwardsi* (~4.73 indiv./km²; Wright et al., 2012), *P. diadema* (~7.3 indiv./km², Irwin 2008), but similar to extremely rare *P. perrieri* (~3.1 indiv./km², Banks et al. 2007) which shows the smallest distribution of all sifaka species. By comparison, western sifakas have even larger densities: *P. tattersalli* (~34 to 90 indiv./km², Quéméré et al. 2010), *P. coquereli* (5 to 93 indiv./km², Kun-Rodrigues et al. 2014), *P. coronatus* (49 to 309 indiv./km², Salmona et al. 2013), *P. verreauxi* (41 to 1036 indiv./km², Norscia and Palagi 2008).

The remaining *Propithecus candidus* population is declining due to hunting; there is no taboo or fady protecting them (Patel et al. 2005, Jenkins et al. 2011, Golden and Comaroff 2015, Loudon et al. 2016); habitat disturbance from slash-and-burn agriculture and selective logging for rosewood, ebony, and other hardwoods (Patel 2007), as well as artisanal mining. Although, they have long been known to inhabit Marojejy NP, Anjanaharibe-Sud SR, as well as the Makira Natural Park; until recently there has been little information on their occurrence in COMATSA (Corridor Marojejy –Anjanaharibe-Sud–Tsaratanana). Goodman et al. (2003) first observed *P. candidus* at two sites (820m and 1200m of elevation) on the western side of the Betaolana Corridor between Marojejy and Anjanaharibe-Sud (Figure 1, Table S1).

Rabearivony et al. (2015) report an impressive biodiversity survey in the COMATSA corridor which connects Marojejy NP, Anjanaharibe-Sud SR, and the Tsaratanana Strict Nature Reserve. The COMATSA corridor is a large continuous forest block covering ap-

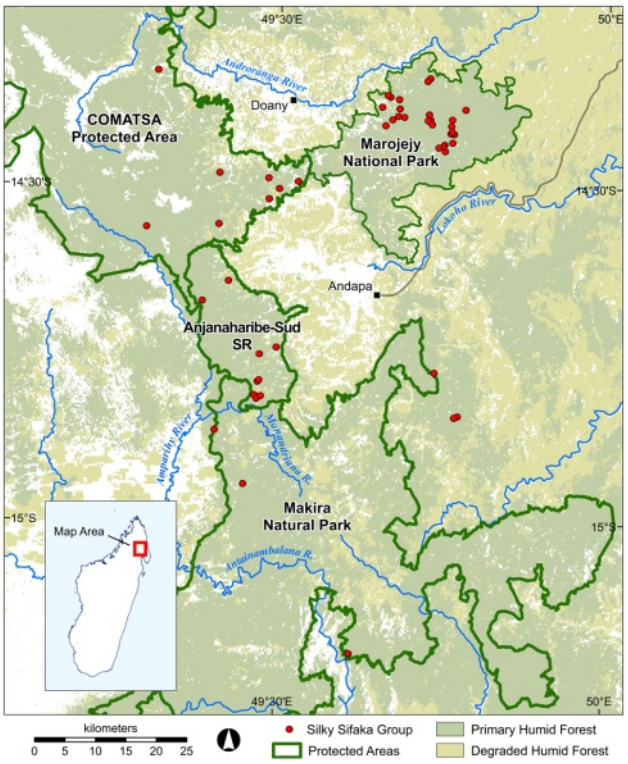

Figure 1. Location of known *Propithecus candidus* groups in northeastern Madagascar (Data for map available in Table S1). Each red dot represents a different silky sifaka group (not sightings of all encounters). Within Marojejy National Park and Anjanaharibe-Sud Special Reserve, more groups are expected to be found between 650m and 1950m of elevation. Map by Paul Atkinson.

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proximately 250,000 hectares including a wide elevational range from 75m to 2800m of altitude. It is humid forest with approximately 2500mm of rainfall annually. Although it has received provisional protected area status through WWF since 2010, it was not yet confirmed as a new protected area in February 2016. During this survey, 248 vertebrate species were observed including the Critically Endangered *Propithecus candidus*. Importantly, Rabearivony et al. (2015) provide the first observations of *P. candidus* from the Anjiabe and Antsahabe sites. The Anjiabe site (hosting a likely small and isolated population of *P. candidus*) is particularly remarkable and represents the northernmost location for the species outside of Marojejy (Figure 1). However, both of these sites are still south of the Androranga River, which still remains the northern limit for the species (Figure 1, Table S1, Patel 2014).

CORRECTION TO RABEARIVONY ET AL. (2015)

A few minor corrections need to be made to Table 1 and to Supplementary file #4 of Rabearivony et al (2015). The authors report that the elevational range of *Propithecus candidus* is from 775m to 1625m but the known elevational range for the species is from 235m in Makira at the Andaparaty Rabeson site (Rajaonarison and Patel 2013, Rajaonarison 2015) to 1875m in Marojejy (Sterling and McFadden 2000). Furthermore, the authors also report, without providing evidence, that *P. candidus* has been kept in captivity as a pet and that it is threatened by the pet trade. Although Reuter et al. (2014) estimated that ~28,000 lemurs may have been kept as pets in Madagascar since 2010, no *P. candidus* have yet been observed as pets (Mittermeier et al. 2010, Patel 2014). Indeed, *P. candidus*, like other sifakas (such as the *P. diadema* and *P. tattersalli* which lived at Duke Lemur Center, but have not survived), are likely to be extremely difficult to raise in captivity due to their highly specialized diet. Although recent seasonal dietary (Sato et al. 2016) and nutritional analyses (Ganzhorn et al. 2016) offer some new insights, *P. candidus* has never been kept in captivity, and none are found in any zoos anywhere in the world (IUCN 2015).

CORRECTION TO RASOLOFOSON ET AL. (2007)

A minor correction is also warranted to the lemur survey paper of Rasolofoson et al. (2007). These authors observed *Propithecus candidus* at two sites: (i) Manandriana (research camp location: E049°27'37.3", S14°49'53.3") which is just north of the Manandriana River and (ii) Anjanaharibe (Andaparaty research camp location: E049°36'50.8", S15°11'17.1") which is just north of the Antainambalana River. These were important discoveries, as *P. candidus* had never before been observed at the Manandriana site, and were only rumored to be present at the Anjanaharibe (Andaparaty) site. At the time of publication, the boundaries of Makira were not yet fully demarcated, and the Manandriana site was believed to be inside the Makira Natural Park. In 2015, the Anjanaharibe-Sud SR was extended, and it is now clear that the *P. candidus* found at the Manandriana site are actually inside Anjanaharibe-Sud SR. These corrections impact the population management of this species and are addressed to the Wildlife Conservation Society that manages the Makira Natural Park and to Madagascar National Parks which manages Anjanaharibe-Sud SR.

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SUPPLEMENTARY MATERIAL.

Available online only.

Figure S1: Location of known *Propithecus candidus* groups in northeastern Madagascar.

Table S1: Coordinates, localities, dates, and sources for *Propithecus candidus* records used in Figure S1.

Document S1: Rajaonarison and Patel 2013

Document S2: Rajaonarison 2015

SHORT NOTE

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A proposal for ethical research conduct in Madagascar

Lucienne Wilmé[I], Patrick O. Waeber[II], François Moutou[III], Charlie J. Gardner[IV], Onja Razafindratsima[V], John Sparks[VI], Christian A. Kull[VII], Barry Ferguson[VIII], Wilson R. Lourenço[IX], Paulina D. Jenkins[X], Lolona Ramamonjisoa[XI], David A. Burney[XII], Porter P. Lowry II[XIII]

Correspondence:
Lucienne Wilmé
Email: lucienne.wilme@mobot-mg.org

ABSTRACT

Ethical conducts are gaining importance in times of increased globalization and research efforts. This paper presents a code of ethical conduct for researchers who plan to publish their studies with the journal Madagascar Conservation & Development. This paper will be subject to continuous adaptations and discussions.

RÉSUMÉ

Les conduites éthiques gagnent en importance en ces temps marqués par une mondialisation croissante et une augmentation du volume des travaux de recherche. Cette contribution présente un code de conduite éthique destiné aux chercheurs qui envisagent de publier leurs études dans le journal Madagascar Conservation & Development. Cet article fera l'objet de discussions et sera régulièrement adapté.

THE NEED FOR CODES OF ETHICAL CONDUCT

The end of World War II saw the adoption of a number of codes of ethical conduct in various disciplines of research. For example, the Nuremberg Code of 1948 stated that "the voluntary consent of the human subject is absolutely essential" (Shuster 1997: 1436), implying that research subjects should give prior consent and especially, that benefits stemming from such research must outweigh the risks involved. Most countries have published ethical codes of conduct for research, and several research institutions have organized ethical committees to help their researchers follow and adopt common principles, framing social science approaches, ecological surveys or research with and on animals (e.g., Britt 1984, Directive 2010/63/EU, Biller-Andorno et al. 2015, South African Council for Social Services Professions). Since the end of the 20th century, Germany, the United States and other countries have consolidated research activities under the umbrella of 'Research Integrity' to impose principles on national universities, as well as universities receiving grants (Mayer 2015). The 2010 Singapore statement, an outcome of three consecutive world conferences on research integrity, lists 14 responsibilities: integrity, adherence to regulations, research methods, research findings, authorship, publication acknowledgment, peer review, conflict of interest, public communication, reporting irresponsible research practices, responding to irresponsible research practices, research environments, and societal considerations (Resnik and Shamoo 2011, cf. details in Wagner and Kleinert 2011). Along the same lines an article in The Lancet (Anonymous 2012) with the title "Promoting research integrity: a new global effort" provides a thorough list of principles and responsibilities in research.

In the years 2002–2007, global research expenditures increased by almost 50%, while the number of researchers grew some 25% and the number of scientific publications went up almost 30% to some 1.58 million per year (Royal Society of London 2011). One of the most important metrics for excellence in science is the number and quality of publications produced. In a world where 'publish or perish' remains a guiding principle (Garfield 1996), researchers are facing growing challenges when it comes to producing knowledge and understanding for the dissemination and transfer to policy- and decision-makers (Gluckman 2014). Consequently, pressures on researchers to deliver results are high, and

I Missouri Botanical Garden, Madagascar Research & Conservation Program, BP 3391, Antananarivo 101, Madagascar
II Forest Management and Development, Department of Environmental Sciences, Swiss Federal Institute of Technology Zurich, 8092 Zurich, Switzerland
III French Mammal Society & French Agency for Sanitary Security, France
IV School of Anthropology and Conservation, Durrell Institute of Conservation and Ecology (DICE), University of Kent, Kent CT2 7NR, UK
V Department of BioSciences, Rice University, 6100 Main St. MS 170, Houston, TX 77005, USA
VI American Museum of Natural History, Department of Ichthyology, Division of Vertebrate Zoology, Central Park West at 79th Street, New York, NY 10024, USA
VII Institut de Géographie et Durabilité, Géopolis – Mouline, Université de Lausanne, 1015 Lausanne, Switzerland
VIII Madagascar Environmental Justice Network, Fort-Dauphin, Madagascar
IX Muséum national d'Histoire naturelle, Sorbonne Universités, Institut de Systématique, Evolution, Biodiversité (ISYEB), UMR7205-CNRS, MNHN, UPMC, EPHE, CP 53, 57 rue Cuvier, 75005 Paris
X The Natural History Museum, Cromwell Road, London SW7 5BD, UK
XI Silo National des Graines Forestières, Ambatobe, Antananarivo 101, Madagascar
XII National Tropical Botanical Garden, Kalaheo, HI 96741, USA
XIII Missouri Botanical Garden, Africa and Madagascar Program, P.O. Box 299, St. Louis, Missouri 63166-0299, USA

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the temptation to cut corners is real. Hence, research must adhere to the highest possible ethical and legal standards. Too few journals have an explicit code of conduct; nevertheless, a number of internationally renowned conservation journals are already adhering to ethical principles for published research. For example, the journal Biodiversity and Conservation has a list of ethics in their Ethical Responsibilities of Authors and Compliance with Ethical Standards, as do the other Springer journals, Biological Conservation refers to its Policy and Ethics paragraph for ethical conduct for publishing, and Oryx has an explicit Code of Conduct that is based on the British Sociological Association (BSA 2002), and this is under current revision to adapt and address new challenges occurring at global scale. The Society of Conservation Biology has developed a code of ethics based on 15 points; more than 90 researchers provided statements and amendments for the final document (Box 1).

Box 1. Examples of journals with published codes of conduct

Biodiversity and Conservation
https://www.springer.com/gp/authors-editors/journal-author/journal-author-helpdesk/before-you-start

Biological Conservation
https://www.elsevier.com/journals/biological-conservation/0006-3207/guide-for-authors#6001

Oryx
http://www.oryxthejournal.org/index.php/for-authors/instructions.html#coc

Society of Conservation Biology
http://conbio.org/about-scb/who-we-are/code-of-ethics

Madagascar, for example, has an ethics committee with oversight for research to be conducted in protected areas. However, despite the fact that Madagascar's unique biodiversity and degree of endemism has attracted hundreds of international research, conservation and development institutions (Waeber et al. 2016), resulting in thousands of research publications over the past decades (e.g., Wilmé et al. 2012), no such research committee exists that includes research universities. The production of knowledge is a contribution which is not tangible in the short term, but may be beneficial in the longer term. We believe that if researchers adhere to a code of conduct that is broad in scope but allows the explicit delineation of specifics, there can be a win-win situation (e.g., between researchers and policy makers, researchers and conservationists, or researchers and farmers). Here we propose a code of conduct for researchers contributing articles to the journal Madagascar Conservation & Development, which is applicable to both foreign and national researchers. However we encourage all researchers operating in Madagascar to abide by the code, regardless of the journals to which they intend to submit their research outputs.

RECOMMENDATIONS FOR ETHICAL CONDUCT

Ethical guidelines are becoming more important since a steadily increasing globalization is affecting growing numbers of countries, institutions and people. This increased risks of contamination and spreading of diseases, for human beings as with influenza epidemics (bird flu) but also for biodiversity as for example the transmission of pathogens to frogs (e.g., Phillott et al. 2010, Kolby et al. 2015) or bats (Blehert 2012).

The rationale for code(s) of conduct should be to ensure that the potential negative impacts of research are avoided or minimized, while the benefits of research should be maximized both for the researchers and for all relevant stakeholders. For example, the Swiss government proposes 11 principles for successful partnerships in research for development: (i) set the agenda together, (ii) interact with stakeholders, (iii) clarify responsibilities, (iv) account to beneficiaries, (v) promote mutual learning, (vi) enhance capacities, (vii) share data and networks, (viii) disseminate results, (ix) pool profits and merits, (x) apply results, and (xi) secure outcomes (Stoeckli et al. 2014). Research institutions in the developed world, private and public, have credible integrity systems that can be followed. Some initiatives have been taken across Africa to promote responsible conduct in research and identify strategies to promote research integrity (Kombe et al. 2014). They propose two broad approaches: "(1) promotion of institutional and individual capacity building to instill a culture of responsible research conduct in existing and upcoming research scientists, and (2) developing deterrent and corrective policies to minimize research misconduct and other questionable research practices" (Kombe et al. 2014: 8–9). In the following, we present a list of recommendations that take into account the Swiss system and Kombe et al. (2014).

Recommendations are meant to assist researchers and students from Madagascar and outside in planning their publishing with the journal Madagascar Conservation & Development. The list should be reviewed and updated on a regular basis, as part of an interactive and iterative process. Many technical fields need their own ethical guidelines, which are hopefully consistent with the spirit at least of this document. The current list is non-exhaustive, but rather aims to provide a broad overview of guidelines to abide; we also refer to already well-established codes of conduct where appropriate.

Researchers must seek appropriate and necessary permissions from home but also local institutions and authorities. Researchers should always respect local culture, beliefs and rights; researchers must consider the interests of stakeholders in research planning and management. Research should conform to the standards set out by an internationally recognized source (example: research involving lemurs should adhere to the principles for the ethical treatment of non-human primates set out by the American Society of Primatologists, https://www.asp.org/welfare/socialhousingpolicystatement.cfm). Research outcomes should be shared fairly with the project counterparts.

Minimize the impact on animals, plants and ecosystems in general. Whenever possible, non-invasive methods that do not require capture and/or euthanasia/preservation of animals should be used. Always conform to the highest standards of animal welfare for animal capture and handling, which should also be performed by those with the appropriate qualifications in animal capture (cf. Guidelines of the American Society of Mammalogists, Sikes et al. 2011). Avoid the accidental introduction and dispersal of non-native terrestrial and aquatic species in the ecosystem (e.g., avoid bringing propagules or any other living forms from outside the system or from one site to another). Collection must be

justified and should only take place if it is essential for the integrity of the research, and the number of specimens must be kept to the minimum necessary to conduct the research. Always consider alternative methods to animal capture and euthanasia, such as sampling of hair and feces, photographs and/or sound recordings, including for the description of new taxa (e.g., Thalman and Geissman 2005, Ito et al. 2013). If specimens are to be kept abroad, all national and international laws should be respected (e.g.: Nagoya Protocol, CITES). Seed samples collected should conform to national regulations and be registered in Silo National des Graines Forestières - SNGF and a duplicate deposited in the national seedbank. Any experiments involving live animals (e.g., feeding experiments, applied behavioral research) should conform to established policies on ethical treatment of animals (e.g., Sherwin et al. 2003) and should only use lawfully acquired animals.

To prevent animal-animal, animal-human, and human-animal transfer of disease, high levels of personal hygiene should be maintained (e.g., avoid having a sick person observing animals in the field, or handling them; maintain a certain distance between the observer and the animal subjects to reduce incidence of disease transmission). Researchers should use established protocols to avoid transmission of pathogens to animals (e.g., Phillott et al. 2010, Blehert 2012, Kolby et al. 2015). Care should be taken to prevent any biopiracy of indigenous knowledge and biological products that might otherwise occur through removing indigenous rights for maximizing economic profits (e.g., Efferth et al. 2016, application of Nagoya Protocol).

The following recommendations on social aspects are based on the British Sociological Association's standards (BSA 2002): "Respect for human rights and a commitment to promoting social justice are at the core of social work practice throughout the world" (BASF 2012: 5). Research that involves people should hold the well-being, dignity, and rights of the participants as key principles to inform the research strategy (Hammett et al. 2015: 88). Ethical research with humans avoids abuses of power, does not harm participants, and relies on voluntary and informed participation. Ethical research with humans is not restricted to specific practices such as consent forms or anonymity; it involves the entire research project, including questions like the following (Hammett et al. 2015: 92): "Is the research well designed and respectful of participants' time and interests? Has due thought been given to whom the beneficiaries are of the research, and what their role is (if any) in designing the research? Are there any benefits for the local community from the research?" The safety and well-being of participants is paramount. This includes physical aspects (e.g., health risks) and social aspects (e.g., emotional distress) and legal aspects (e.g., compromising information). For the latter two, appropriate strategies regarding anonymity of participants as well as confidentiality of data (e.g., security of interview transcripts) should be put in place and communicated with participants (although see St. John et al. 2016).

CONCLUSION

Before inception of any research on the ground, researchers first need to seek approval of their project at their home institution. In a next step, research must have received all necessary authorisations in the country where it was carried out. The current paper is a proposition intended for researchers to publish in the journal Madagascar Conservation & Development; it will be subject to continuous updating to allow coping with global and international demands, challenges, and changes.

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CONFLICT OF INTERESTS

The authors declare no conflict of interests

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