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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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Approaching the limits

"A committee is a group that keeps minutes and loses hours."
— Milton Berle

From the 4th – 17th December 2016, the parties of the Convention for Biodiversity held their 13th conference in Cancún, Mexico. At the event, a revised red list was produced. On the list are some species featured for the first time. Others were down-listed, or moved into categories more dire than previously was the case.

This convention – along with others of a similar nature – should not be viewed as tools fashioned to improve the current situation: more accurately, these conventions serve as an index of sorts, there to follow the ongoing decrease of biodiversity. In reality, very few recommendations presented and accepted during these conferences, are ever followed through by means of any effective actions. This lack of action plans being implemented is often ascribed to other 'more pressing' priorities.

A noteworthy perspective not taking into account any specific countries, politicians or NGOs, is that of human demography. It is estimated that Homo sapiens is some 200,000 years old. While it is impossible to know the population of the species' founding stock, we might say that it took [200,000 years minus 200 years] for the population to reach the one billion mark, globally speaking. Effectively, it means that this figure was reached by the year 1800. Some two centuries later, by 2011, the world's human population totalled seven billion (Roberts 2011). Whatever the criteria may be, it has to be said that this is impressive. During my own lifetime, the human population has already multiplied by three.

Simultaneously, we are only too aware of a great many species whose global populations are estimated to have declined by more than 90% of their known numbers (Kolbert 2014). What will happen next? Where is this leading to? Nobody really knows. However, a few comments may be worth consideration. In ecology and in epidemiology, certain phenomena can only occur above certain thresholds, like population density or population quantity. In the case of human beings, we may soon be facing situations where new possibilities of diffusion, be it of microorganisms, genes, or of any risk factor, will become a reality (Quammen 2012, Moutou and Pastoret 2015). In the case of non-human species, we may increasingly witness the consequences of the Allee effect, where a population drops below the size required for it to function normally. This leads to an increased probability of the species' extinction, regardless of the cause of the death of its last member (Courchamp et al. 2008).

I would add one more comment. For millennia, we never gave thought to – nor envisioned, the limits of our planet and finite nature of our resources. Now however, we find we are facing a horizon which is no longer moving away or retreating as we keep on advancing. Many scientists have cautioned that, close to these limits, the global laws and theorems lose validity. If this is right, maybe we are left with one last chance. The window of time in which to seize this eventuality, may be very short. Let us hope we will not miss it.

François Moutou
French Mammal Society
France
Email: francoismoutou@orange.fr

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ARTICLE

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Value of useful goods and ecosystem services from Agnalavelo sacred forest and their relationships with forest conservation

Tabita N. Randrianarivony[I, II], Tefy H. Andriamihajarivo[I], Aro V. Ramarosandratana[II], Fortunat Rakotoarivony[I], Vololoniaina H. Jeannoda[II], Alyse Kuhlman[III], Armand Randrianasolo[IV], Rainer Bussmann[IV]

Correspondence:
Tabita N. Randrianarivony
Missouri Botanical Garden,
Madagascar Research and Conservation Program,
BP 3391, Antananarivo 101, Madagascar
Email: tabivony2001@yahoo.fr

ABSTRACT

Agnalavelo forest provides necessary natural resources to people who live in its surroundings (Communities of Mahaboboka, Amboronabo and Mikoboka in southwestern Madagascar). The aim of this study is to document goods and ecosystem services provided by Agnalavelo forest to local people and to use it as a tool for the identification of priorities for forest conservation. Oral interviews were undertaken from 2010–2013 with local communities living in the vicinity of Agnalavelo forest. This study also investigated forest resource use, conducted inventories of tree species, estimated wood biovolume, as well as the economic benefits associated with conservation due to carbon storage. Finally, we recorded felled trees caused by honey collection inside the forest and determine the cause for their slaughter. An investigation with the ownership of rice fields irrigated by rivers taking sources from Agnalavelo forest was also conducted. Based on field surveys and analysis, communities living around Agnalavelo forest draw substantial benefits for their daily life from the forest. Goods and ecosystem services are classified in the three categories (provisioning, cultural and regulating services) according to the Millennium Ecosystem Assessment (MEA). Cultural services are highly valuable to local people as the forest is a dwelling place for their ancestor's spirits. Agnalavelo forest provides Non Wood Forest Products (NWFPs) such as foods, tools, magic and medicinal plants and fresh water for local people. It is able to store 152 tons of carbon per hectare which is very important for climate regulation in this dry southwestern part of Madagascar. Endemic tree species hosting bee hives are often felled during harvesting period. Agnalavelo forest conservation is very important not only with regards to its biodiversity but also for goods and services that it provides to local population.

RÉSUMÉ

La forêt d'Agnalavelo, sur les communes de Mahaboboka, Amboronabo et Mikoboka, au sud-ouest de Madagascar, fournit les ressources naturelles nécessaires pour la population riveraine. L'objectif de cette étude a été de documenter les biens et les services éco-systémiques fournis par la forêt d'Agnalavelo pour les populations locales, afin d'identifier les priorités pour la conservation de cette forêt. Des enquêtes auprès des communautés vivant à proximité de la forêt Agnalavelo ont été menées, entre 2010 et 2013, sur l'utilisation des ressources forestières. Des inventaires écologiques des espèces d'arbres forestiers utilisés ont été réalisés pour déterminer le biovolume ainsi que les bénéfices économiques associés à la conservation de la forêt d'Agnalavelo par le stockage de carbone. Un inventaire des arbres abattus le long d'une piste forestière et les causes de leurs abattages ont complété l'étude, ainsi que des enquêtes auprès des propriétaires des rizières irriguées par les rivières qui prennent leurs sources dans la forêt d'Agnalavelo qui ont révélé que les communautés riveraines en tirent profit dans leur quotidien. La forêt d'Agnalavelo offre trois catégories de biens et services écosystémiques, à savoir les services d'approvisionnement, les services culturels et les services de régulation. Les services culturels sont les plus importants pour la population locale. La forêt d'Agnalavelo fournit les produits forestiers non ligneux tels que de la nourriture, des outils, des plantes considérées comme magiques, des plantes médicinales et de l'eau douce pour la population locale. La forêt d'Agnalavelo peut stocker 152 tonnes de carbone par hectare, valeur importante pour la régulation du climat dans cette région sèche de Madagascar. Des arbres appartenant à des espèces endémiques de Madagascar et abritant des ruches sont souvent abattus lors de la récolte du miel. La conservation de la forêt d'Agnalavelo est importante aussi bien pour la biodiversité qu'elle héberge que pour les biens et services des écosystèmes qu'elle fournit à la population locale.

I Missouri Botanical Garden, Madagascar Research and Conservation Program, BP 3391, Antananarivo 101, Madagascar
II Department of Plant Biology and Ecology, Faculty of Science, University of Antananarivo, BP 566, Antananarivo 101, Madagascar
III Department of Anthropology, Washington University, St. Louis, MO 63130-4899, USA
IV William L. Brown Center, Missouri Botanical Garden, P.O. Box 299, St. Louis, MO 63166-0299, USA
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BACKGROUND

Forests make significant direct and indirect contributions to human welfare (Wu et al. 2010). Globally, nearly 1.6 billion people rely on forest goods and services (Vedeld et al. 2007). The concept of ecosystem services, defined as benefits people draw from ecosystems (Westman 1977, World Resources Institute 2003), was developed to better understand the interdependence between ecosystems and societies.

In Madagascar, one of the mega-diverse countries in the world (Mittermeier et al. 2005), about 80% of the population lives in rural areas (UNESCO 2012). Malagasy people are heavily dependent on natural resources for food, shelter, health care, clothing and tools (Sarrasin and Ramahatra 2006). There have been several recent attempts to estimate carbon stocks in Malagasy forests and their value, e.g., the Makira project in the North (Chappelle 2013), in Zahamena Mantadia (Wendland et al. 2010), in Menabe (Sommerville et al. 2010) and in Tsitongambarika (Olsen et al. 2011).

Before Agnalavelo was established as a New Protected Area (NPA), it was considered a sacred forest. For many years, this forest has been governed by local rules. Before Missouri Botanical Garden (MBG) began their conservation project of this sacred forest, the *Tompontany* (traditional owners of the forest) provided consent to protect the forest within other organizations, like WWF (1998–2002) and SAGE (2003–2006). The creation of the NPA Alandraza Agnalavelo, which received its final decree of legal protection in April 2015, can be considered an administrative process to strengthen the traditional protection of the *Tompontany*.

From the beginning of the NPA's creation, in 2007, the *Tompontany* have already agreed to protect Agnalavelo forest. Minutes containing their agreements are included in documents for the NPA's creation (Andriamihajarivo et al. 2008). The desires of *Tompontany* to enhance the cultural values of their forest, such as zebu sacrifice in the forest, were included within the document and were considered during the conservation process.

This study is part of an ongoing process, led by the Missouri Botanical Garden (MBG), aiming to establish a new protected area in Agnalavelo forest. While working with communities, MBG noticed that Agnalavelo is important to local livelihoods. Agnalavelo not only offers forest products and environmental services to the local communities, but it also supplies socio-cultural benefits to them. Goods and ecosystem services used and collected by the local population are highlighted in this study. They include: Non-Wood Forest Products (NWFPs) defined as "goods of biological origin other than wood, derived from forests, other wooded land and trees outside forest" (FAO 1999), wood products and other cultural benefits from the forest. The results of this study will be used as a tool to support decision making for Agnalavelo forest management.

Agnalavelo is a sacred forest to local people because they believe it to be a dwelling place for their ancestor's spirits (Horning 2004). Due to this fact, the local population has strict traditional rules to maintain the sacredness of the forest. However, Agnalavelo is still threatened by fires, illegal logging for house construction and hunting. Forests that are considered sacred may be better protected and less disturbed (Jones et al. 2008, Andriamarovololona and Jones 2012, Uyeda et al. 2014). The reinforcement of traditional authorities' power and integration of local rules in forest management would be among strategies to be considered within the Agnalavelo conservation plan.

The aim of this study was to determine goods and ecosystem services provided by the Agnalavelo forest to local people and to use it as a tool to identify priorities on forest conservation program. More precisely, we aimed to identify what benefits will be lost if Agnalavelo forest disappear.

METHODS

STUDY SITE. Agnalavelo forest is located in southwestern Madagascar, in the district of Sakaraha; it is surrounded by the communes of Mahaboboka, Mikoboka and Amboronabo, between E044° 06' and E044° 13', S22° 36'and S22° 44' and in the midst of an arid region (Figure 1). Due to its remoteness, entering the forest by crossing to Fiherenana River and hiking through mountains is very difficult. Thus, Agnalavelo forest can be considered a remote area distant from paved roads. It covers 4,044 ha (Andriamihajarivo 2014), on a volcanic basalt substrate, with a maximum elevation of 1350 m asl (Sourdat 1976). The climate in Agnalavelo forest is characterized by a sub-humid microclimate (Moat and Smith 2007), with an average rainfall of 1000 mm and a mean annual temperature of 20ºC (Ferry and L'Hôte 1998). Agnalavelo forest is characterized by four types of vegetation, namely the humid forest, the sub-humid forest, the dry forest and the xerophytic bush formation (Randrianarivony 2015). They are hosts to many endemic species, such as lemurs (*Propithecus verreauxi* A. Grandidier, *Microcebus murinus* J. F. Miller and *Cheirogaleus medius* E. Geoffroy), other mammals (*Microgale nasoloi* Jenkins & Goodman, *Pteropus rufus* Tiedemann and *Cryptoprocta ferox* Bennett) (Soarimalala 2007, Andriamihajarivo et al. 2008), reptiles and birds (*Neomixis viridis* Sharpe, *Foudia omissa* Rothschild) (Raherilalao 2006). So far, 403 species of vascular plants grouped in 100 families and 249 genera were collected from the forest (Andriamihajarivo et al. 2008), 73% of them are endemic to Madagascar. Three endemic plants families (Asteroperiaceae, Sphaerosepalaceae, Sarcolaenaceae) were inventoried (Andriamihajarivo et al. 2008). Two new plant species from Agnalavelo forest (*Spondias tefyi* J.D. Mitch., D.C. Daly and Randrian, *Aloe analavelonensis* Letsara, Rakotoarisoa and Almeda) were recently published (Mitchell et al. 2012, Letsara et al. 2012).

Nine ethnic groups (Bara, Antanosy, Antandroy, Masikoro, Vezo, Sakalava, Mahafaly, Betsileo and Antaisaka) live in the surrounding of Agnalavelo forest (Horning 2004). Bara is the respectful and the dominant ethnic group also called *Tompontany*, they are primarily cattle herders and farmers. The educational level is quite low in all villages surrounding the forest. Only people who live in

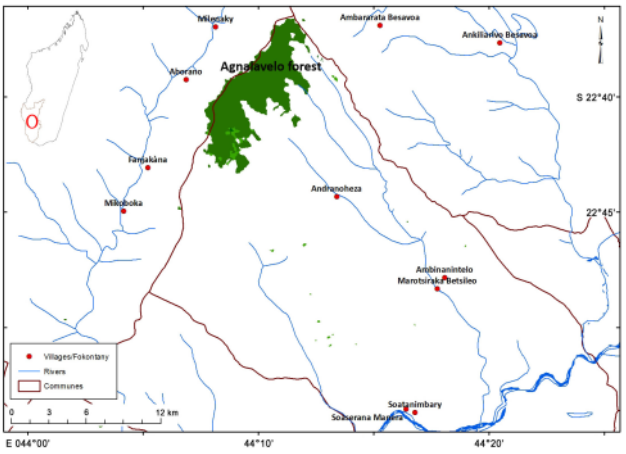

Figure 1. Localization of Agnalavelo forest.

larger villages, namely Ambinanintelo and Soatanimbary (Mahabokoka), Besavoa (Amboronabo) and Fanjakàna and Soatanà (Mikoboka) have completed primary school. Even in these larger villages, only three teachers are responsible for all children at the primary school level. Educational infrastructure is grossly inadequate. In some villages like Soatanimbary and Besavoa; villagers' houses are used as classrooms. In Andranoheza, the classroom has been destroyed and Ambinanintelo do not have any classroom. Markets for food and goods exist only in the three rural communes (Mahaboboka, Amboronabo and Mikoboka). Churches are only found in Besavoa and in Fanjakàna. All houses in each village are adobe with roof of straw.

DATA COLLECTION

INTERVIEWS. Semi-structured oral interviews (Alexiades 1996) were performed from December 2010 to August 2011 in order to document all useful plants collected from Agnalavelo forest. Before conducting interviews, we obtained informed consent from administrative and traditional authorities as well as from each participant. Communities living in 34 villages from seven *fokontany* (lowest administrative subdivision in Madagascar) were selected for the survey. We randomly selected at least 50 individuals in each rural community including male and female participants who were between 15 and 81 years old. Spiritual healers, traditional healers, traditional midwives, carpenters and house builders were especially targeted as informants and a total of 259 informants were interviewed.

In addition, structured interviews (Grosshans and Chelimsky 1991) were performed in all villages in Andranoheza valley from June to September 2013. Heads of households, owner of rice fields irrigated by rivers sourced from Agnalavelo, were chosen as informants. Structured interviews were also conducted with community members who were known to harvest honey and those who used water from the forest for their daily needs. From these interviews, we were able to estimate the area of rice fields irrigated by water from Agnalavelo and to quantify the amount of honey potentially produced from hives in the forest (Appendix 1).

FOREST INVENTORIES. Tree species were recorded in order to estimate the population of trees within the forest and get some other information, such as the volume of trees and useful trees and the species composition of the forest (Scott and Gove 2002). Forest inventories, carried out from August 2011 to March 2013, were used also to assess the biomass of trees in the forest and to evaluate the carbon fluxes between aboveground forest ecosystems and the atmosphere (Houghton 2003, Grace 2004). Inventories were conducted in 11 plots of 0.1 hectares (50m x 20m). The location of plots depended on the presence of species used and considered useful, such as wood for coffin, medicinal or magical plants, in Agnalavelo forest. Collection of data in each plot was done according to Braun-Blanquet methods (Poore 1955). Within each plot, we recorded the diameter at breast height (dbh) at 1.3m, and height at first branched for trees. These parameters were recorded with trees having diameters greater than or equal to 10 cm, which is the usual minimum diameter considered in most inventories of woody forests. Specimens of unknown species were collected for identification. Dendrometric parameters such as density (Pascal 2003), basal area (Dawkins 1952, Gounot 1969), biovolume, aboveground tree biomass (Brown 1997), carbon stocks with aboveground biomass and the equivalent in sequestrated CO2 by Agnalavelo forest (Aalde et al. 2006, Mugnier et al. 2009) were estimated (Table S1).

LOGGING INVENTORY. This survey included identification of logged trees in the forest and determination of the reason for their logging. Three main trails in the eastern and western part of the forest were inspected. Furthermore, newly established trails in the forest were visited when local guides suspected them as potential indicators of new sites for logging. Reasons for logging were determined by inspecting the area around a cut tree. The opinions of local guides were taken into consideration during the assessment. The charred remains of wood, pieces of honeycombs and the presence of holes in the trunk were valuable clues that related to honey harvesting. Scattered bark was a good indicators for logging. The tree diameter was a crucial parameter considered in the case of tree logging for coffins. Local names of logged trees were given by local guides and their scientific names were determined by collecting left dried branches and leaves as vouchers.

MONETARY VALUATION OF GOODS AND ECOSYSTEM SERVICES. We assessed the relative worth of goods and ecosystem services from this forest (Farber et al. 2002). It has been argued that valuation of goods and ecosystem services is useless and does not correctly reflect the real significance of biodiversity (Heal 2000). However the Aichi targets for the new strategic plan for 2020, request that "values for biodiversity be integrated into national development strategies and national accounts" (Conservation on Biological Diversity 2011). Therefore assessment of the value of goods and ecosystem services of Agnalavelo forest could be integrated into the accounting system at a national level. Several methods have been developed by economists to evaluate goods and ecosystem services (Vuletić 2009, Groot et al. 2012), based on True Economic Value (TEV) in which goods and ecosystem services are divided into two categories: Use Value and Non-use Value (Aylward et al. 2003). For this study, we used market price (Aylward et al. 2003) of useful goods and ecosystem services provided by Agnalavelo forest. Real market prices were used to assign monetary value to goods and ecosystem services used by local people, such as: non-wood forest products (honey), crop (rice), carbon storage and water for irrigation and daily needs. Market value of carbon is however highly variable but we based our calculation on market values of carbon of Makira forest, in northeastern Madagascar, which is at $10 per ton of carbon (Chappelle 2013).

RESULTS

PROVISIONING SERVICES. This category includes useful wood products, especially wood for coffins and other useful non-wood forest products. The non-wood forest products collected form Agnalavelo forest were food, raw botanical material for medicines, plant fibers, utensils, animal products such as honey, and meat from wild animals like tenrecs and lemurs. During the ethnobotanical survey, 350 useful species were cited by 259 informants. Among them, 65 species cited by 117 informants, were collected only from Agnalavelo forest. The other useful species were collected in dry forests and grasslands near the villages.

WOOD FOREST PRODUCTS. Three endemic species are harvested for coffins: *Dalbergia purpurascens* Baill. (Fabaceae), locally known as *Magnary* (Figure S1), *Syzygium sakalavarum*

(H. Perrier) Labat & G.E. Schatz called *Rotsy* and *Albizia tulearensis* R. Vig. called *Mendoravy*. Results from the forest inventory highlighted that mean height of *Dalbergia purpurascens* is 14m with a standard error (SE) of 0.47 and could reach 20m and its average dbh is 35cm (±3.35 SE) and sometimes could reach 1m, with a mean density of about 38 individuals/ha (± 27.32 SE) and a mean aboveground biomass of 37 tons/ha (± 0.19 SE). In 2016, the cost of a coffin is about $180 (~MGA540,000 at the time of this research) on average, equivalent to 8 months of wages for people living in the surroundings of the forest. By having access to resource from Agnalavelo forest, local people can save this amount at funeral time. From 2013 to 2015, we have recorded 12 deaths for which coffins were made from wood taken from Agnalavelo forest. Whether Agnalavelo forest is a protected area, collecting *Magnary* as wood for coffin in this forest is part of local people's right. Eighteen tree species cited by 38 informants were illegally collected from Agnalavelo forest for house construction. From inventory of logged trees, we found 55 stumps of *Zanthoxylum tsihanimposa* H. Perrier (Rutaceae), *Erythroxylum firmum* Baker (Erythroxylaceae), and *Capurodendron gracilifolium* Aubrév. (Sapotaceae) and *Viguieranthus ambongensis* (R. Vig.) Villiers (Fabaceae) logged and used in house buildings (Figure S2).

NON-WOOD FOREST PRODUCTS. Food: Tubers of two wild species of *Dioscorea*, i.e. *D. soso* Jum. & H. Perrier, and *D. ovinala* Baker (Dioscoreaceae) are harvested in the forest when men keep their cow there. These species are also highly sought during hunger period. Fruits of *Sygyzium sakalavarum* (Myrtaceae), *Adansonia za* Baill. (Malvaceae) and *Spondias tefyi* (Anacardiaceae) were collected as edible.

Raw material for medicines: Thirty-one species were cited by 69 informants as medicinal plants, among which, 12 species cited by, at least 4 informants: *Vepris unifoliolata* (Baill.) Labat, M. Pignal & O. Pascal, *Emilia humifusa* DC., *Suregada eucleoides* Radcl.-Sm., *Celtis gomphophylla* Baker, *Toddalia asiatica* (L.) Lam., *Ocotea trichantha* Baker, *Gouania pannigera* Tul., *Strychnos henningsii* Gilg, *Rinorea greveana* Baill., *Ensete perrieri* (Claverie) Cheesman and *Piper* cf. *borbonense* (Miq.) DC. (Figure S2). *Toddalia asiatica* (Rutaceae), *Strychnos henningsii* (Loganiaceae) were cited by more than 15 informants for the treatment of digestive system disorders, by grinding the stems into powder to be used as infusion for the stomach-ache and belly-ache.

Utensils: Nine species cited by 16 informants were used for tool handles: *Wielandia bojeriana* (Baill.) Petra Hoffm. & McPherson (Euphorbiaceae). A hard slender wood locally known as *Tsifolaboay* was frequently cited for this purpose.

Fiber: Bark of *Bauhinia decandra* Du Puy & R. Rabev. (Fabaceae) and *Spondias tefyi* (Anacardiaceae) were used to produce rope during visits to the forest. Two individuals of *B. decandra* were found debarked during the inventory.

Products from animals: *Tenrec ecaudatus* Schreber, locally known as *Sora*, wild birds *Voro* and lemurs (*Propithecus verreauxi*, *Lemur catta*, *Eulemur rufifrons*) locally known as *Sifaky*, are illegally hunted in the forest (Figure S3). They are believed to be fatty and delicious meat for villagers during hunger periods. Moreover, people may hunt these animals because killing a zebu is too expensive and zebus are highly valued by local people. Six households from Mikoboka village practice illegal lemur hunting in Agnalavelo forest twice a month, from September to January each year. A group of four men normally hunt four to eight lemurs for local consumption during each hunting session.

Honey production: honey, locally known as *Antely* is collected in Agnalavelo forest from March to July for consumption and also for local sale. Bees are found in holes of felled or living trees (Figure S4). Big trees with a dbh averaging 50cm, such as *Ocotea trichantha* and *Euphorbia mandravioky* often contained honeycombs. We inventoried 25 individuals of endemic species such as *Rinorea greveana*, *Ocotea trichantha*, *Capurodendron gracilifolium*, *Vitex lanigera* and *Euphorbia mandravioky* felled down during honey harvesting. The quantity of honey collected in the forest was approximately 20 liters/household/month during the harvesting period. Selling of wild honey (~ $1, MGA3000/liter), was a part-time activity of 4% of households (n = 12). Five households collected honey in the forest twice a year and the remaining once a year. When local consumption is taken into account, honey production of the Agnalavelo forest is estimated at 350 liters/year and brought $350/year (~MGA1,050,000) to local people.

Fresh water supply: five rivers (Manadabo, Manasay, Betaola, Andranoheza and Sakalomory) take their source from Agnalavelo forest. Domestic water and water used for irrigation of crop fields at Andranoheza valley are supplied by these rivers. Because water sourced from Agnalavelo is drinkable, fresh water for domestic use is obtained straight from river. This is particularly important as it contributes to water procurement to villages during the dry season. A total of 288 households, with an average of eight persons per household, consumed 60 liters per household per day. About 1200 ha of rice fields in Andranoheza valley were irrigated with river water from Agnalavelo forest. Those rice fields produce about 2000 tons of rice per year as some villagers harvest twice a year (production of 1.5 ton per hectare of rice). Water process in Madagascar vary from at $0.2/m^3$ (in Antananarivo, from the national company that manages water and electricity to households *JIro sy RAno MAlagasy* or JIRAMA) to 6.25 $/m^3$ for people in dry regions who pay water fetched by day laborers. In our site study, the income from irrigated field was estimated as three times the income from a non-irrigated one. This adds value to services using water from Agnalavelo forest.

CULTURAL SERVICES. Local people strongly believe that Agnalavelo forest was a hiding place for their parents during the colonization period, to escape from mandatory labor. They believe that their ancestor's spirits stay in the forest. After independence, village elders, especially the head of village (*Lonaky*) and spiritual healers (*Ombiasy*), acknowledge services rendered by the forest by saving their ancestors from persecution and declared it a place of worship. Ancestor's spirit living in the Agnalavelo forest became advisors to spiritual healers for the uses of plants. Therefore, local people believe that part of their blessings and their success for agricultural activities comes from the forest.

A large part of informants, 90% of 259 informants interviewed during surveys, confirmed that they were aware of Agnalavelo forest sacredness. These informants considered Agnalavelo as a place where they can communicate with their ancestor. They describe it as a living forest that gives life and foods, brings success and is also a source of healing and protection. Thirty-four informants (26 male and 8 female) reported taboos in Agnalavelo forest, which included taking pork meat, gold and silver jewelry and kitchen utensils to the forest, not respecting the cleanliness of the forest and having sexual intercourse in the forest. Thirty-one informants (27 male and 4 female) underlined the need of

worship and veneration of the ancestor prior to any activities in the forest. People who worked in the forest must bring a zebu, red rum, perfumed scent, perfumed oil, tobacco, money or a black cock as gifts or sacrifices to the ancestor's spirits, depending on their activities. The *Lonaky* have specified that collection of wood for coffins must be preceded by a zebu sacrifice, otherwise ancestor's spirits would be displeased and could kill another villager. Similarly, the *Lonaky* stated that if there was no sacrifice of zebu in Agnalavelo forest the rain would be scarce during the year.

Thirty-seven plant species cited by 67 informants were collected from Agnalavelo forest for cultural purposes. Those plants were believed to possess magical properties and are referred as "magical plants" in this study. The use of those magical plants helped local people to beg their ancestor for blessings (*fitahy*), for disenchantments (*fanalaha voriky*), success in their agricultural activities (*fieboa*), to get more power within the community (*fandrorota*), protection against bad spells, bandit attacks, bad weather and misfortune (*fiaro*), to charm girls, women or men (*aoly lahy*, *aoly ampela*) and to bring fertility to women who could not have children (*fananan'anaky*). More than six informants reported that the following plant species were used for cultural purposes: *Suregada eucleoides*, *Tannodia cordifolia* Baill., *Ocotea trichantha*, *Dracaena xiphophylla* Baker, *Albizia tulearensis*, *Vepris boiviniana* (Baill.) Mziray, *Vepris unifoliolata*, *Artabotrys madagascariensis* Miq. and *Drynaria willdenowii* (Bory) T. Moore (Table S2). A talisman containing stem powder of *Suregada eucleoides* was believed to give power and to bring success to its users. *Ocotea trichantha* was used to confer fertility to women who could not have children. *Dracaena xiphophylla* was used to improve the user's seductive ability and raise the chance to attract future spouse.

The bark of *Ficus tiliifolia* Baker (Moraceae) was made into clothing in the past. The branches and leaves of *Wielandia elegans* (Phyllanthaceae) were used for soap.

EDUCATIONAL VALUE. Agnalavelo forest is well-preserved; and national and foreign researchers are still investigating its flora and fauna. Students from local primary and secondary schools in Mahaboboka have participated in environmental education within the conservation project of Agnalavelo forest. Students were trained about biodiversity found in dry and sub-humid forest and their conservation.

REGULATING SERVICES. According to the results of forest inventories, the number of trees in each plot varied from 65 to 127 with an average of 104 trees (± 6.69 SE). Tree density in Agnalavelo forest was on average 1038 individuals/ha (± 6.69 SE), with an average height of 12m (± 0.09 SE) and an average dbh of 20cm (± 0.44 SE). The basal area of Agnalavelo forest was estimated at 47 m^2/ha (± 0.003 SE). The assessment of aboveground biomass yielded 321 tons (± 0.03 SE) per hectare, with 152 tons of carbon per hectare stored by living material, which is equivalent to 559 tons of CO_2 sequestrated per hectare. This study showed about $6 million benefits associated with conservation due to carbon storage values. The function of the natural forest ecosystem to regulate water flow and rain frequency could decrease the impacts of climate change in the surroundings of Agnalavelo forest and at national level. Finally, during our study, we observed that flowers, especially *Argomuellera* Pax (Euphorbiaceae), are used by bees as a source of nutrients.

DISCUSSION

This study highlights that goods and ecosystem services from Agnalavelo forest provide an important contribution to local people's wellbeing, such as provisioning, cultural and regulating services. Before the establishment of protected areas, forests were considered as fertile land for slash and burn activities locally called *Hatsaka* (Milleville et al. 2001, Blanc-Pamard 2002, Aubry and Ramaromisy 2003). They also provide timber, firewood and charcoal (Dirac Ramohavelo 2009, Grafl et al. 2009). As Agnalavelo is a sacred forest, the local rules forbid slash and burn activities, collection of timber for construction and exploitation of timber for fuel and charcoal inside the forest. However, they can perform some activities like collection of medicinal and magical plants and plants for tool handles when visiting the forest for other reasons. The quantity of medicinal and magical plants and food collected in the forest is low and seems to not negatively impact species survival or lead to ecosystem degradation (Randrianarivony 2015).

Agnalavelo forest is classified as a category III (Natural Monument) protected area by IUCN. It is a place where people are traditionally permitted some forest access for collecting wood for coffin, honey, medicinal and magical plants in the forest. Local rules called *Dina* and management plans have been established and are generally effective. Unlike in other parts of Madagascar (Menabe Central Region, Manompana corridor) (Dirac Ramohavelo 2009, Urech et al. 2012), trade of goods and services (charcoal, food and honey) is not an important source of income for local population around Agnalavelo forest. Trade of honey harvested from the forest represents a very low income. Nevertheless, honey collection can become problematic as many trees were felled for this purpose. Banning honey collection for sale was recently included in the management plan of Agnalavelo forest (Andriamihajarivo 2014). Moreover, local people are not allowed to cut trees during honey collection, so introduction of tools such as harness and ropes to honey collectors is needed, then a beekeeping project needed to be established for the local population (Randrianarivony 2015).

Timber harvesting for coffins is the most important service that local people benefit from Agnalavelo forest. No trade of wood was observed from surroundings of Agnalavelo compared to trade of precious wood such as rosewood and ebony from the SAVA region in northeastern Madagascar (Randriamalala and Liu 2010).

Lemurs were hunted and eaten by 2% of households surrounding the Agnalavelo forest. This rate is relatively low compared to data reported from other regions in Madagascar, with 17% of households in Betampona and to 49% in Makira (Golden et al. 2014). However, in 1972, Griveaud and Peyrieras observed more than five groups of four *Propithecus verreauxi* a day in Agnalavelo forest, but 40 years later, we only recorded one group of two *Propithecus verreauxi* a day. This suggests that hunting activities may have reduced the number of lemurs in the forest.

A huge quantity of rice is produced from fields in Andranoheza valley; however, we noticed that local people still have difficulty finding food during dry season. This fact is due to the custom of Bara people to give high importance to zebu. During rice harvesting period, people sell 2/3 of their production to buy cattle or exchange rice for cattle.

Taboos, cultural and ritual values of forests or species are common to many forest patches throughout Madagascar. As the case of forest in the Central Menabe and forest patches in the

Androy Region (Tengö et al. 2004, Dirac Ramohavelo 2009), Agnalavelo forest is a place where Tompontany believe they receive instructions from their ancestors and where most plant species for talismans and for magical remedies are collected. Since Bara in that region believe that Agnalavelo is a dwelling place of their ancestor's spirits (Horning 2004), cultural services from the forest play important roles in customs and ritual ceremonies.

Contrary to other studies undertaken worldwide and in Madagascar (Jones et al. 2008, Dudley et al. 2009, Uyeda et al. 2014), there are neither plant nor animal species or sacred groves in Agnalavelo forest that are taboos for hunting or for collection. The forest is entirely sacred, and the southeast part of the forest (Ankokoky) is the most sacred site where zebu sacrifice must take place. Horning (2004) reported on prohibited, permitted and prescribed activities in the Agnalavelo forest and found that people from Andranoheza valley and villagers from Amboronabo paid more attention on obeying rules. Our data on forest structures (unpublished) indicates that threats and pressures on the forest begin to be visible in the southwest part of the massif, near Mikoboka. Immigrants, who have settled in Mikoboka, do not believe anymore in the sacredness of the forest, illegally collect wood for construction and illegally hunt lemurs in the forest. Like in other sacred sites (Dirac Ramohavelo 2009, Dudley et al. 2009, Bhagwat and Rutte 2006), traditional values and sacredness of Agnalavelo forest is being challenged by the arrival of immigrants and evangelist Christians that are opposed to worshipping of ancestor as idolatry, and by the arrival of westernized culture, which affects the younger generation. Local youths are influenced by the use of modern medicine and use of the technology in communication.

The role of sacredness and taboos in conservation is widely accepted in Madagascar (Fauroux 1997, Lingard et al. 2003, Cinner 2007) and elsewhere (Tengö et al. 2004, Dudley et al. 2009). Thus, integrating traditional authority in conservation strategy by enforcing traditional rules and the power of *Lonaky* should be considered in the management plan of Agnalavelo forest, and everybody should strictly follow traditional rule prior to any activities in the forest.

Some studies were undertaken to estimate values for the carbon storage functions of rainforests; for example in Makira, Zahamena-Mantadia, Tsitongambarika and Congo forests (Meyers 2001, Hockley and Razafindralambo 2006, Nasi et al. 2009, Olsen et al. 2011). Estimated carbon that Agnalavelo forest (152 tons of carbon per hectare) can stock is quite similar to that estimated by Hockley and Razafindralambo (2006) for the Zahamena-Mantadia Corridor (148 tons of carbon per hectare) but lower than carbon stocks in Makira (286 tons/ha) found by Meyers (2001), in Tsitongambarika III (200 tons/ha) estimated by Olsen et al. (2011) and in Congo forest (185 tons/ha) by Nasi et al. (2009). Because most trees in Agnalavelo are tall, we expected that Agnalavelo had the highest estimate of carbon stocks in this southwestern part of Madagascar. Recreational value is lower than that reported in Groot et al. (2012) because Agnalavelo forest is located in a remote area. Value of hydraulic services and biodiversity from Agnalavelo forest is important in this dry southwestern part of Madagascar. Regarding the use of medicinal plants from the forest, botanical materials for medicine are mostly collected in dry forest and in remnant forests near villages.

In the present study, the estimation of carbon stocks is a gross value. It does not include CO_2 emission caused by fires to increase grazing areas, and some agricultural activities already discussed (Cairns 2002). The valuation of services and goods does not take the conservation effort by stakeholders into account, nor the time spent during the collection of provisioning services in the forest.

CONCLUSIONS

Apart from ecological and cultural services, Agnalavelo forest provides provisioning services (water, beehives and coffins) at local, regional and national levels. Associated conservation benefits (carbon storage, honey collection and water for irrigation of Andranoheza valley) demonstrate why the conservation of Agnalavelo forest is important.

Agnalavelo forest is the best candidate for carbon sequestration in southwestern Madagascar and villagers living in the vicinity of the forest could benefit from a community-driven development program, using the money from the sale of carbon credits. The data related to valorization of services could be helpful for decision-making, and also as a tool for environmental education. The assessment of services from Agnalavelo forest illustrates the contribution of ecosystems to social and economic wellbeing.

According to local belief, some plants are considered as magic and having supernatural effects because they grow in a sacred place. Local villages receive protection from their ancestor by using those magic plants. The sacredness of Agnalavelo forest must be emphasized to visitors of the forest and to immigrants. We suggest education programs about goods and ecosystem services from Agnalavelo forest to encourage people to adhere again to traditional rules.

Most of services such as NWFP, biodiversity and cultural services are non-market services, even if some products (e.g., honey) are intended for sale in the local market. Those non-market services are highly valued by local communities and are part of their cultural identity.

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SUPPLEMENTARY MATERIAL.

Available online only.

Appendix 1. Questionnaire guide used during the oral interview.

Table S1. Equations for the estimation of each dendrometric factor

Table S2. List of the most useful species from Agnalavelo sacred forest.

Figure S1. A: Cut Magnary for coffin in Agnalavelo forest (photo by Tabita N. Randrianarivony); B: coffin made by Magnary (photo by Tefy H. Andriamihajarivo).

Figure S2. Wood illegally collected for house construction in Agnalavelo forest (photo by Tabita N. Randrianarivony).

Figure S3. Dead body of a lemur in the forest. (photo by Tefy H. Andriamihajarivo).

Figure S4. Tree as beehive with honey in the Agnalavelo forest. (photo by Tabita N. Randrianarivony).

ARTICLE

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Three new species of *Grosphus* Simon 1880, (Scorpiones: Buthidae) from Madagascar; possible vicariant cases within the *Grosphus bistriatus* group of species

Wilson R. Lourenço[I], Lucienne Wilmé[II]

Correspondence:
Wilson R. Lourenço
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, France
Email: arachne@mnhn.fr

ABSTRACT

A revised redescription is proposed for *Grosphus bistriatus* Kraepelin 1900. Three new species, associated with both *G. bistriatus* and *G. ankarafantsika* Lourenço 2003 are described. Some comments on biogeographic aspects linking the new species with both *G. bistriatus* and *G. ankarafantsika* are also provided.

RÉSUMÉ

Une nouvelle description révisée est proposée pour *Grosphus bistriatus* Kraepelin 1900. Trois nouvelles espèces associées à *G. bistriatus* et *G. ankarafantsika* Lourenço 2003 sont décrites. Des remarques sur les aspects biogéographiques portant sur les nouvelles espèces ainsi que sur *G. bistriatus* et *G. ankarafantsika* sont également formulées.

INTRODUCTION

As already outlined in recent papers, a considerable number of new species have been added to the genus *Grosphus* Simon, in recent years (Lourenço & Wilmé 2015a,b). Among these various cases, some of the recently described species showed some clear associations with other members of this genus sometimes described more than 100 years ago. It is well established that the taxonomy of *Grosphus*, one of the several endemic genera in Madagascar, is notably complicated, particularly aspects of species' delimitations. For a more detailed discussion about the characters used in the taxonomy of *Grosphus*, see Lourenço (2014), Lourenço and Wilmé (2015a,b) and Lourenço et al. (2007, 2009).

In an attempt to stabilize the taxonomic positions of *Grosphus bistriatus* and *G. limbatus* (Pocock 1889), Lourenço (2003), proposed a redescription of these two species. Prior to this publication, both species had been reported from numerous sites on the island; many of these records certainly being misidentifications (Lourenço 1996). The taxonomic status of *G. limbatus* was finally clarified in a recent publication (Lourenço and Wilmé 2015a). For taxonomic details refer also to Lourenço (2003).

For quite a long period, the precise identity of *Grosphus bistriatus* appeared somewhat confused. This species was described by Kraepelin (1900) on the basis of two specimens (syntypes) collected near Tulear in the South of Madagascar. Fage (1929) proposed a redescription based on several specimens from different localities including some from the 'Massif d'Ambre' and 'Maevatanana' in the North range of the island. One of the syntypes, deposited in Paris and preserved in alcohol, was probably already faded when Fage examined it. For instance, the coloration described by Fage was based on the other specimens. The morphology of the basal middle lamellae of the female pectines, illustrated by Fage (1929), also differs from that of the syntype. In his diagnosis of *G. bistriatus*, Lourenço (1996) accepted the redescription proposed by Fage (1929) and indicated the presence of the species in the 'Réserve naturelle intégrale n° 7, de l'Ankarafantsika); a misidentification once again confirmed by Lourenço (2001).

The subsequent study of freshly collected material of *Grosphus bistriatus* from the 'type locality' (region of Tulear), brought clarification as to the coloration and patterns of pigmentation of the species. In addition, the precise morphology of the basal middle lamellae of female pectines was confirmed and described (Lourenço 2003). Finally, the population distributed in the Ankarafantsika Reserve was confirmed as being a different new species, described as *G. ankarafantsika* Lourenço 2003.

In the present note, we comment and confirm once more the status of *Grosphus bistriatus*, and a new redescription is proposed based on further material collected in the region of Tuléar. Three

I 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, France
II Missouri Botanical Garden, Madagascar Research & Conservation Program, BP 3391, Antananarivo 101, Madagascar

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other new species are also described, associated both with *G. bistriatus* and *G. ankarafantsika*. Some biogeographic comments are also added, in attempt to explain these new cases of disrupted distribution among elements of the previously defined *Grosphus* groups.

MATERIAL AND METHODS

Material related to *Grosphus bistriatus*, *Grosphus ankarafantsika* and the new species are now deposited in Muséum national d'Histoire naturelle, Paris. Illustrations and measurements were produced using a Wild M5 stereomicroscope with a drawing tube and an ocular micrometer. Measurements follow Stahnke (1970) and are given in mm. Trichobothrial notations follow Vachon (1974) and morphological terminology is after Vachon (1952) and Hjelle (1990).

TAXONOMIC TREATMENT

Family Buthidae C. L. Koch 1837
Genus *Grosphus* Simon 1880

REDESCRIPTION OF *Grosphus bistriatus* Kraepelin 1900 (FIGURES 1–4).

Grosphus bristriatus Kraepelin 1900: 14.
Grosphus bistriatus: Kraepelin 1901: 267.
Grosphus bistriatus var. *pallicauda* Strand 1908: 485.
Grosphus bistriatus: Fage 1929: 651.
Grosphus bistriatus: Lourenço 1996: 13.
Grosphus bistriatus: Lourenço 2003:143.

Redescription based on a two males and one female collected in the region N of Tuléar, Ifaty, in dry spiny-bush forest, under leaves, IX/2001 (W. Lourenço)

Morphometric measurements together with those of the new species. Coloration. Basically yellowish. Prosoma: carapace pale yellow with two longitudinal blackish lines behind the median eyes; one small dark spot on the anterior margin and two on the posterior margin which fuses with the longitudinal blackish bands present over the tergites; eyes surrounded by black pigment. Mesosoma: yellowish with two longitudinal blackish bands over tergites I-VI, more densely marked on the posterior half of each. Metasoma: all segments yellow, with some dark pigmentation over the ventral aspect, more dense on the fifth; two diffuse spots present on the dorsal face of segment V. Vesicle yellow with dispersed light brownish spots laterally and ventrally; aculeus reddish-yellow. Venter: coxapophysis, sternum, genital operculum and pectines yellowish; sternites yellow. Chelicerae yellowish, without any variegated pigmentation; only a few dark spots at the base of fingers; fingers reddish. Pedipalps: yellowish globally without any pigmentation. Legs yellowish with discrete brownish variegated pigmentation.

Morphology. Carapace intensely granular; anterior margin almost straight with a weak median concavity. All carinae weak to moderate; furrows moderate. Median ocular tubercle anterior to the center of carapace; median eyes separated by a little more than one ocular diameter. Three pairs of lateral eyes. Sternum between sub-triangular and sub-pentagonal. Mesosoma: tergites with a thin and intense granulation. Median carina moderate in all tergites. Tergite VII pentacarinate. Venter: genital operculum consisting of two subtriangular plates. Pectines: pectinal tooth count 27-30 for males and 24-25 for female; basal middle lamellae of each pecten not dilated in males; elongated and curved in females, widening on proximal half. Sternites smooth with moderately elongated stigmata; VII with four vestigial carinae and a few thin granules. Metasoma: segments I and II with 10 carinae, moderately crenulate. Segments III and IV with 8 carinae, moderately crenulate. Segment V with 5 carinae, the dorsal carinae being only weakly marked. Dorsal carinae on segments I-IV without any posterior spinoid granules. Intercarinal spaces moderately granular. Telson with very few granules on lateral and ventral surfaces; dorsal surface smooth; aculeus moderately curved and shorter than the vesicle; subaculear tooth absent. Cheliceral dentition characteristic of the family Buthidae (Vachon 1963); two distinct basal teeth present on the movable finger, the more basal one being slightly reduced; ventral aspect of both finger and manus with dense, long setae. Pedipalps: femur pentacarinate; Patella with carinae represented by some spinoid granules, only on the internal face; Tibia smooth without carinae, all faces weakly granular to smooth. Fixed and movable fingers with 10/11 oblique rows of granules. Trichobothriotaxy; orthobothriotaxy A-α (Vachon 1974, 1975). Legs: tarsus with numerous short thin setae ventrally. Patellar spurs present on legs III and IV, pedal spurs present on legs I to IV; all spurs strong.

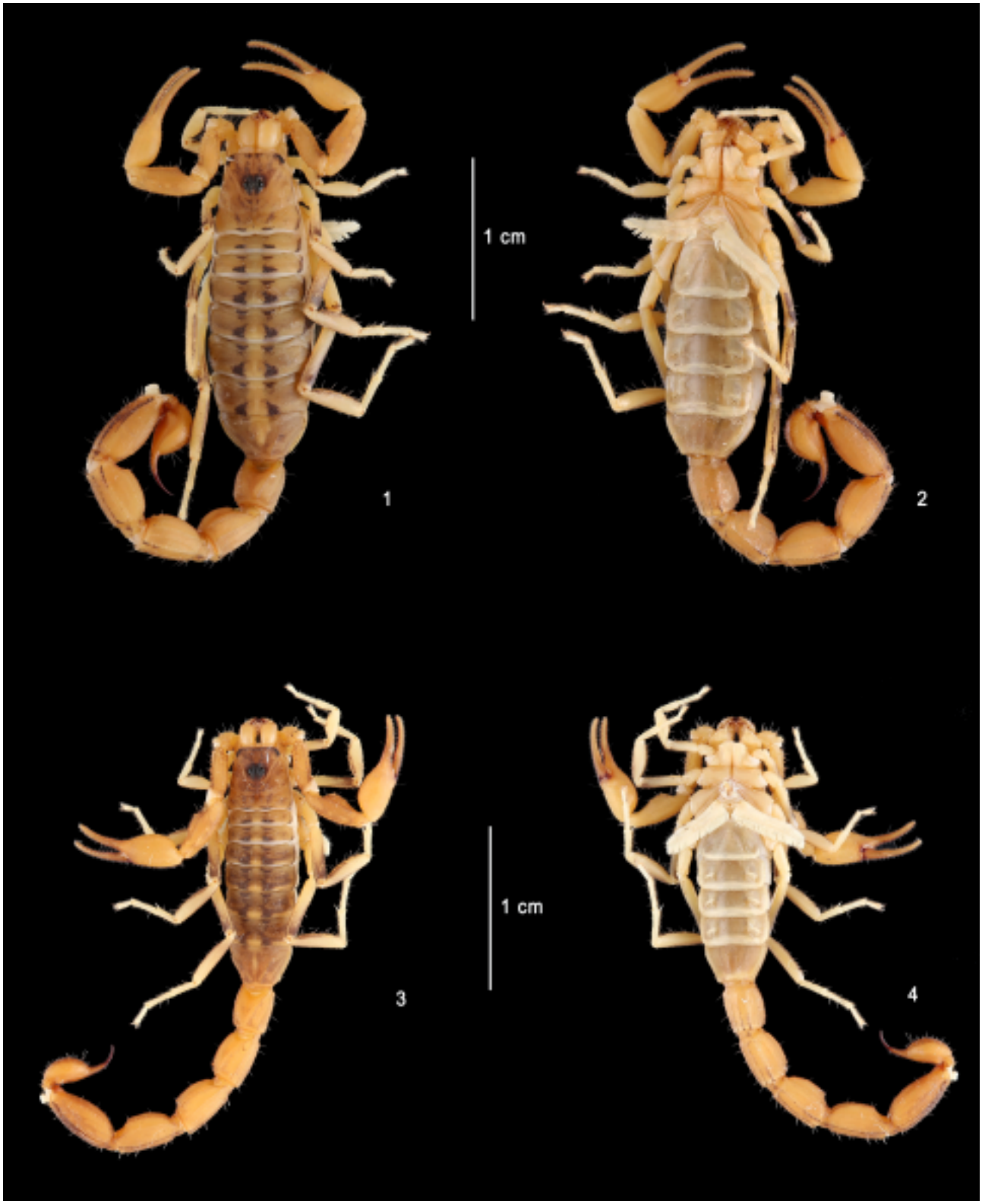
Grosphus eliseanneae sp. n. (Figures 5, 6, 9–15).

Type material. Female holotype. Madagascar, ex-Province d'Antsiranana (Diego-Suarez), Région DIANA. Ambilobe – Beramanja, dry bush vegetation, under log (death wood), X/1969 (J.-M. Betsch). Holotype deposited in the Muséum national d'Histoire naturelle, Paris.

Patronym: The specific name honors Elise-Anne Leguin (MNHN) for her continuous contribution to the study of scorpions.

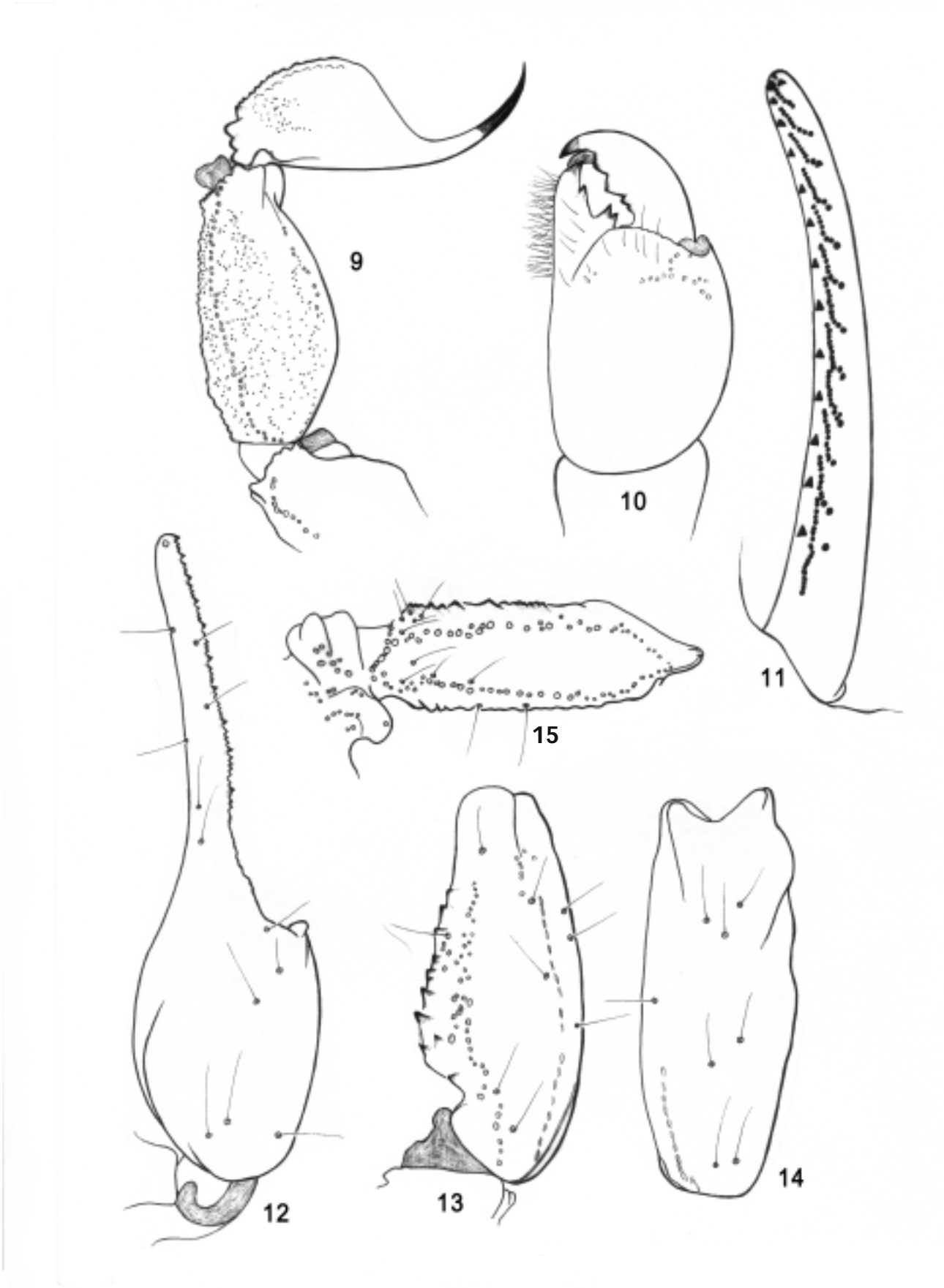
Diagnosis: A scorpion of medium to small size in relation to other species within the genus; female holotype with a total length of 46.6 mm. General coloration yellow to pale yellow with conspicuous dark longitudinal zones on carapace and tergites. Anterior margin of carapace strongly granular. Pectines with 24-24 teeth; basal middle lamellae of each pecten strongly dilated in female, but moderately elongated and covering only the first tooth; constantly narrowing from the base to the apex (diagnostic). Metasomal segments I and II with 10 carinae; III and IV with 8 carinae. Fixed and movable fingers of pedipalps with 11-12 oblique rows of granules respectively. Trichobothriotaxy, orthobothriotaxy, type A-α.

Relationships: The general morphology and pigmentation pattern of the new species shows it to be close to the *Grosphus limbatus / G. bistriatus* group. This group of species is largely distributed in the south-western and central regions of Madagascar. The closest related species however, is *G. ankarafantsika* Lourenço 2003 (Figures 7, 8), described from the Ankarafantsika reserve (see biogeographic section). Both species can be readily



Figures 1–4. *Grosphus bistriatus*. Female and male topotypes. Habitus, dorsal and ventral aspects.

Figures 5, 6. *Grosphus eliseanneae* sp. n. Female holotype. Habitus, dorsal and ventral aspects.
Figures 7, 8. *Grosphus ankarafantsika*. Female topotype. Habitus, dorsal and ventral aspects.



Figures 9–15. *Grosphus eliseanneae* sp. n. Female holotype.
Figure 9. Metasomal segment V and telson, lateral aspect.
Figure 10. Chelicera, dorsal aspect.
Figure 11. Cutting edge of movable finger.
Figures 12–15. Trichobothrial pattern. 12. Chela, dorso-external aspect.
Figures 13, 14. Patella, dorsal and external aspects.
Figure 15. Femur, dorsal aspect.

distinguished by the following characters: (i) pigmentation and spots better marked in the new species, (ii) better marked carinae and granulations on the new species, (iii) basal middle lamellae of pectines less elongate in the new species, covering only the first tooth, whereas in *G. ankarafantiska* the basal lamellae covers 2-3 teeth. Moreover, both species present a totally allopatric distribution.

Description based on female holotype (male unknown). Morphometric values following the description. Coloration. Overall yellow to pale yellow with dark zones on the body and appendages. Prosoma: carapace yellow with an anterior dark brown zone, forming approximately an inverted triangle; lateral edges dark brown; eyes surrounded by black pigment. Mesosoma yellowish, with lateral edges of tergites dark brown. Metasomal segments I to III yellow; IV and V slightly reddish to reddish-yellow; some diffuse pigmentation on the carinae. Telson reddish-yellow without spots; aculeus reddish-yellow at the base and dark reddish on the tip. Venter: coxapophysis, sternum, genital operculum pectines and sternites pale yellow; sternites slightly darker. Chelicerae yellow with some variegated pigmentation; fingers yellow with reddish teeth. Pedipalps yellow with infuscated carinae; rows of granules on chela fingers reddish. Legs pale yellow with slightly infuscated zones.

Morphology. Carapace weakly to moderately granular except on the anterior triangular zone which is more strongly granular; anterior margin with a weak median concavity. All carinae weak; furrows moderately developed. Median ocular tubercle anterior to the centre of the carapace; median eyes separated by approximately one ocular diameter. Three pairs of lateral eyes. Sternum subtriangular in shape. Mesosomal tergites with a moderately marked granulation. Median carina moderately marked in all tergites. Tergite VII pentacarinate. Venter: genital operculum consisting of two suboval plates. Pectines: pectinal teeth count 24-24; basal middle lamellae of each pecten strongly dilated, but moderately elongated, covering only the first proximal tooth; narrowing from the base to the apex. Sternites smooth, with elongated stigmata; VII with weakly marked carinae. Metasomal segments I and II with 10 carinae, moderately crenulate. Segments III and IV with 8 carinae, moderately crenulate. Segment V with 5 carinae. Dorsal carinae on segments II to IV without posterior spinoid granules. Intercarinal spaces moderately to strongly granular. Telson with a moderate to weak granulation over latero-ventral and ventral surfaces; its dorsal surface smooth; aculeus weakly curved and slightly shorter than the vesicle; subaculear tooth absent. Cheliceral dentition characteristic of the family Buthidae (Vachon 1963); two distinct basal teeth present on the movable finger; ventral aspect of both fingers and of manus with dense, long setae. Pedipalps: femur pentacarinate with moderate spinoid carinae; patella with dorsointernal and dorsoexternal carinae and with some spinoid granules on the internal face; chela without carinae and with the internal face smooth. Fixed and movable fingers with 11-12 oblique rows of granules respectively. Trichobothriotaxy; orthobothriotaxy A-α (Vachon 1974, 1975). Legs: tarsus with numerous short thin setae ventrally, forming a brush. Tibial spurs present on legs III and IV, thin and long; pedal spurs present on legs I to IV, moderate to strong.

Morphometric values (in mm) of the female holotype. Total length (including telson), 46.6. Carapace: length, 5.2; anterior width, 3.9; posterior width, 6.1. Mesosoma length, 13.1. Metasomal segments. I: length, 3.5; width, 3.5; II: length, 3.8; width, 3.2; III: length, 4.0; width, 3.2; IV: length, 4.8; width, 3.2; V: length, 6.1; width, 3.1; depth, 2.8. Telson length, 6.1. Vesicle: width, 2.5; depth, 2.3. Pedipalp: femur length, 4.3, width, 1.4; patella length, 5.2, width, 2.2; chela length, 8.3, width, 2.1, depth, 2.2; movable finger length, 5.2.

Grosphus waeberi sp. n. (Figures 16–25).

Type material. Male holotype and male paratype. Madagascar, ex-Province of Mahajanga, Région Sofia, near Maromandia village, IX/2001 (Local people to W. Lourenço). Holotype and paratype deposited in the Muséum national d'Histoire naturelle, Paris.

Patronym: The specific name honors Patrick O. Waeber (ETH Zurich and MWC Madagascar) for his research and dedication to the conservation of some of the most threatened species of the Madagascar biodiversity.

Diagnosis: A scorpion of small size in relation to other species within the genus; male holotype with a total length of 36.5 mm. General coloration yellow to pale yellow with two inconspicuous light brown longitudinal stripes over carapace and tergites. Anterior margin of carapace with a few granules; other zones with a thin granulation. Pectines with 26-27 teeth; (holotype) and 30-29 teeth (paratype); basal middle lamellae of each pecten not dilated in males. Metasomal segments I to III with 10 carinae; IV with 8 carinae; intermediate carinae incomplete on III. Femur and patella of pedipalps with some spinoid carinae, moderately marked. Fixed and movable fingers of pedipalps with 11-12 oblique rows of granules respectively. Trichobothriotaxy, orthobothriotaxy, type A-α.

Relationships: The general morphology and pigmentation pattern of the new species shows it to be close to the *Grosphus limbatus / G. bistriatus* group. This group of species is largely distributed in the South-western and central regions of Madagascar. The closest related species however, is *G. bistriatus* Kraepelin 1900, described from the region of the Tulear (see biogeographic section). Both species can be readily distinguished by the following characters: (i) pigmentation, granulations and carinae much less marked on the new species, (ii) cutting edges of pedipalp fingers with 11-12 rows of granules in the new species vs. 10-11 in *G. bistriatus*, (iii) scopula between chela fingers less marked in the new species, (iv) body and appendages slender in the new species – see morphometric values.

Description based on male holotype and male paratype. Morphometric values following the description. Coloration. Overall yellow to pale yellow with a few dark zones on the body and appendages. Prosoma: carapace yellow with an anterior pale reddish-orange zone, approximately forming an inverted triangle; eyes surrounded by black pigment. Mesosoma yellow, with two inconspicuous longitudinal pale brown stripes. Metasoma: segments I to IV yellowish; V slightly reddish-yellow; some pigmentation on the carinae, better marked on IV-V. Telson reddish-yellow without spots; aculeus reddish, darker on the tip. Venter: coxapo-

Figures 16, 17. *Grosphus waeberi* sp. n. Male holotype. Habitus, dorsal and ventral aspects.

physis, sternum, genital operculum pectines and sternites pale yellow. Chelicerae yellow slightly pigmented at the base of fingers; teeth reddish. Pedipalps yellowish with rows of granules on chela fingers reddish. Legs pale yellow; carinae with slightly brownish zones.

Morphology. Carapace weakly granular except on the anterior triangular zone which is moderately granular; anterior margin with a very weak median concavity, almost straight. All carinae weak to obsolete; furrows moderately developed. Median ocular tubercle anterior to the centre of the carapace; median eyes separated by one ocular diameter. Three pairs of lateral eyes. Sternum sub-triangular in shape. Mesosomal tergites with a very weak granulation. Median carina moderately to weakly marked in all tergites. Tergite VII pentacarinate. Venter: genital operculum consisting of two suboval plates. Pectines: pectinal teeth count 26-27 (holotype), 30-29 (paratype); basal middle lamellae of each pecten not dilated. Sternites smooth, lustrous with elongated stigmata; VII with vestigial carinae and a few granulations. Metasomal segments I to III with 10 carinae, moderately crenulate. Segment IV with 8 carinae, moderately crenulate. Segment V with 5 carinae. Dorsal carinae on segments II to IV without posterior spinoid granules. Intercarinal spaces moderately to weakly granular. Telson with a weak granulation over latero-ventral and ventral surfaces; its dorsal surface smooth; aculeus weakly curved and slightly shorter than the vesicle; subaculear tooth absent. Cheliceral dentition characteristic of the family Buthidae (Vachon 1963); two distinct basal teeth present on the movable finger; ventral aspect of both fingers and of manus with dense, long setae. Pedipalps: femur pentacarinate with moderate spinoid carinae; patella with dorsointernal and dorsoexternal carinae and with a few spinoid granules on the internal face; chela without carinae and with the internal face smooth. Fixed and movable fingers with 11-12 oblique rows of granules respectively. Trichobothriotaxy; orthobothriotaxy A-α (Vachon 1974, 1975). Legs: tarsus with numerous short thin setae ventrally. Tibial spurs present on legs III and IV, thin and long; pedal spurs present on legs I to IV, moderate to strong.

Female unknown.

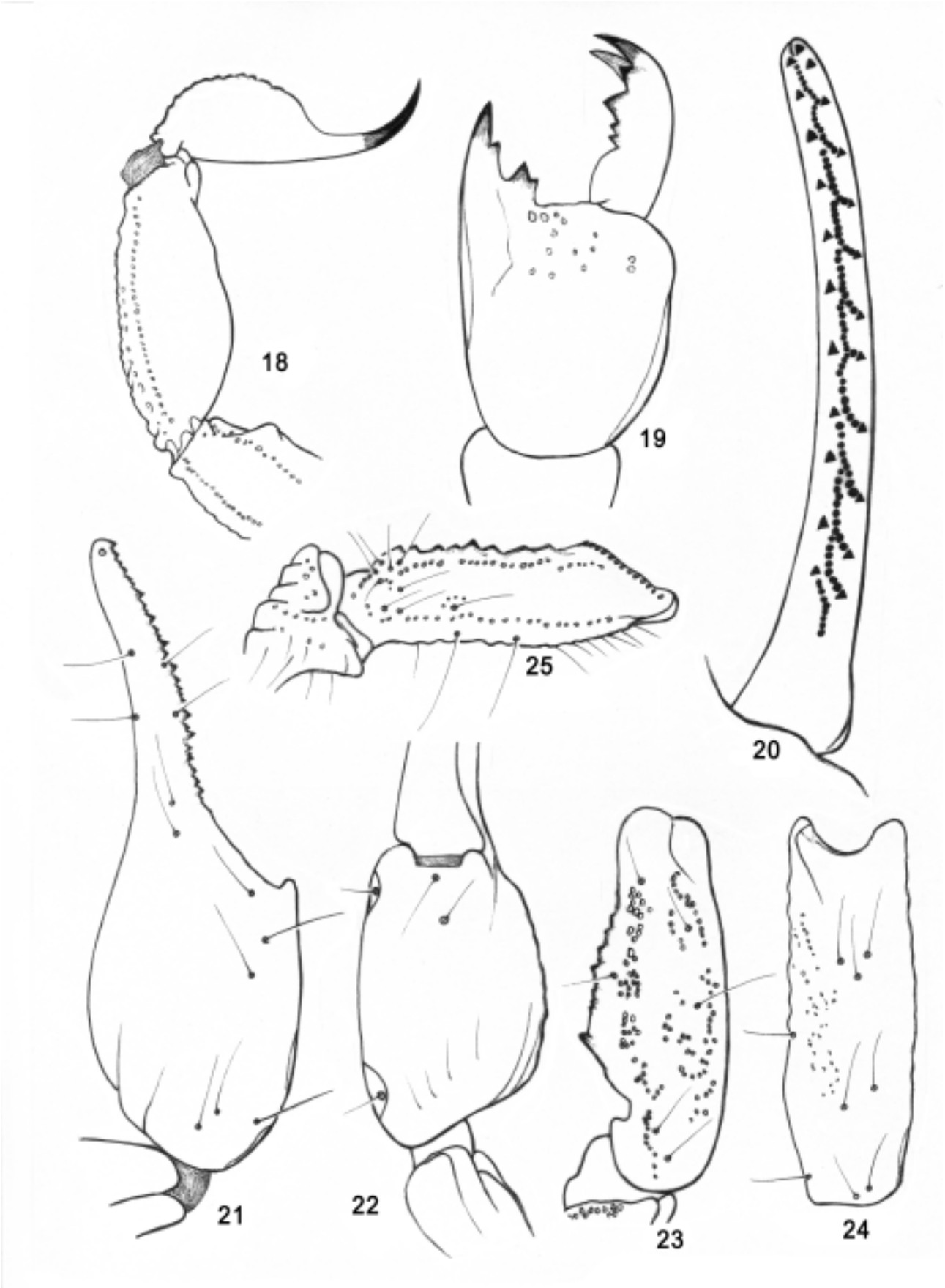
Morphometric values (in mm) of the male holotype of *Grosphus waeberi* sp. n. and a male topotype of *G. bistriatus*. Total length (including telson), 36.5/35.1. Carapace: length, 3.7/3.6; anterior width, 2.7/2.8; posterior width, 3.9/4.2. Mesosoma length, 10.3/9.9. Metasomal segments. I: length, 2.8/2.7; width, 2.3/2.5; II: length, 3.2/3.1; width, 2.2/2.4; III: length, 3.3/3.2; width, 2.2/2.3; IV: length, 3.7/3.6; width, 2.1/2.3; V: length, 4.8/4.5; width, 2.1/2.4; depth, 2.1/2.3. Telson length, 4.7/4.5. Vesicle: width, 1.6/1.8; depth, 1.6/1.8. Pedipalp: femur length, 3.3/3.4, width, 1.1/1.3; patella length, 4.0/4.1, width, 1.4/1.7; chela length, 6.5/6.7, width, 1.8/2.0, depth, 1.8/2.0; movable finger length, 3.7/3.8

Grosphus sabineae sp. n. (Figures 26–35).

Type material. Female holotype. Madagascar, ex-Province de Toliara, Région Androy, Cap Sainte-Marie, VI/1967 (J.-M. Betsch). Holotype deposited in the Muséum national d'Histoire naturelle, Paris.

Patronym: The specific name honors Dr Sabine Jourdan (Paris) for her constant support to the senior author in his researches.

Diagnosis: A scorpion of medium to large size in relation to other species within the genus; female holotype with a total length of 55.7 mm. General coloration yellow to pale yellow with very inconspicuous spots on body and appendages. Anterior margin of carapace emarginated and moderately granular. Pectines with 25-25 teeth; basal middle lamellae of each pecten strongly



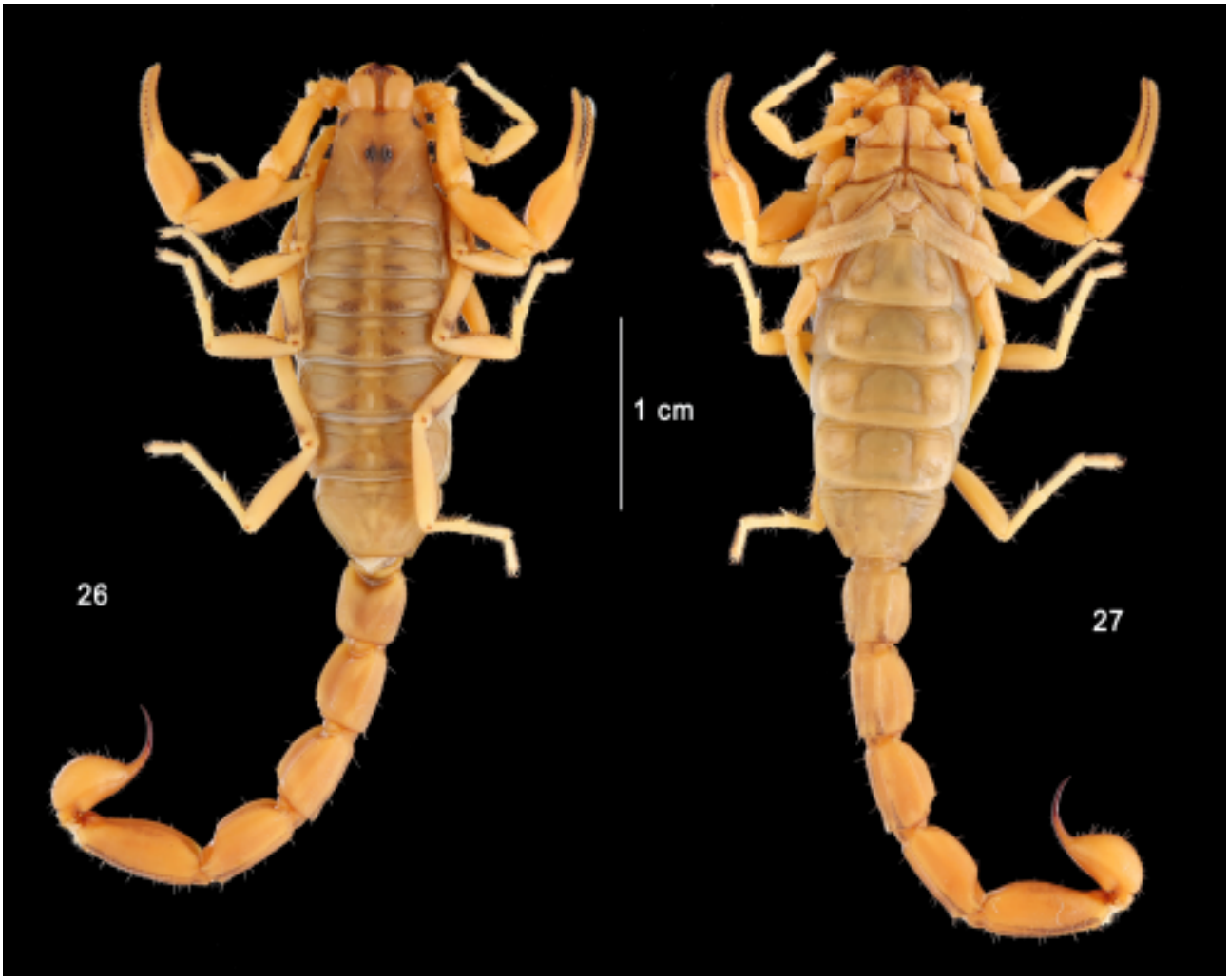
Figures 18–25. *Grosphus waeberi* sp. n. Male holotype.
Figure 18. Metasomal segment V and telson, lateral aspect. Figure 19. Chelicera, dorsal aspect. Figure 20. Cutting edge of movable finger.
Figures 21–25. Trichobothrial pattern. Figures 21, 22. Chela, dorso-external and ventral aspects. Figures 23, 24. Patella, dorsal and external aspects. Figure 25. Femur, dorsal aspect.

dilated in female, moderately elongated and covering only the first proximal tooth. Metasomal segments I and II with 10 carinae; III and IV with 8 carinae. Femur and patella of pedipalps with moderately to weakly spinoid carinae. Fixed and movable fingers of pedipalps with 11-12 oblique rows of granules respectively. Trichobothriotaxy, orthobothriotaxy, type A-α.

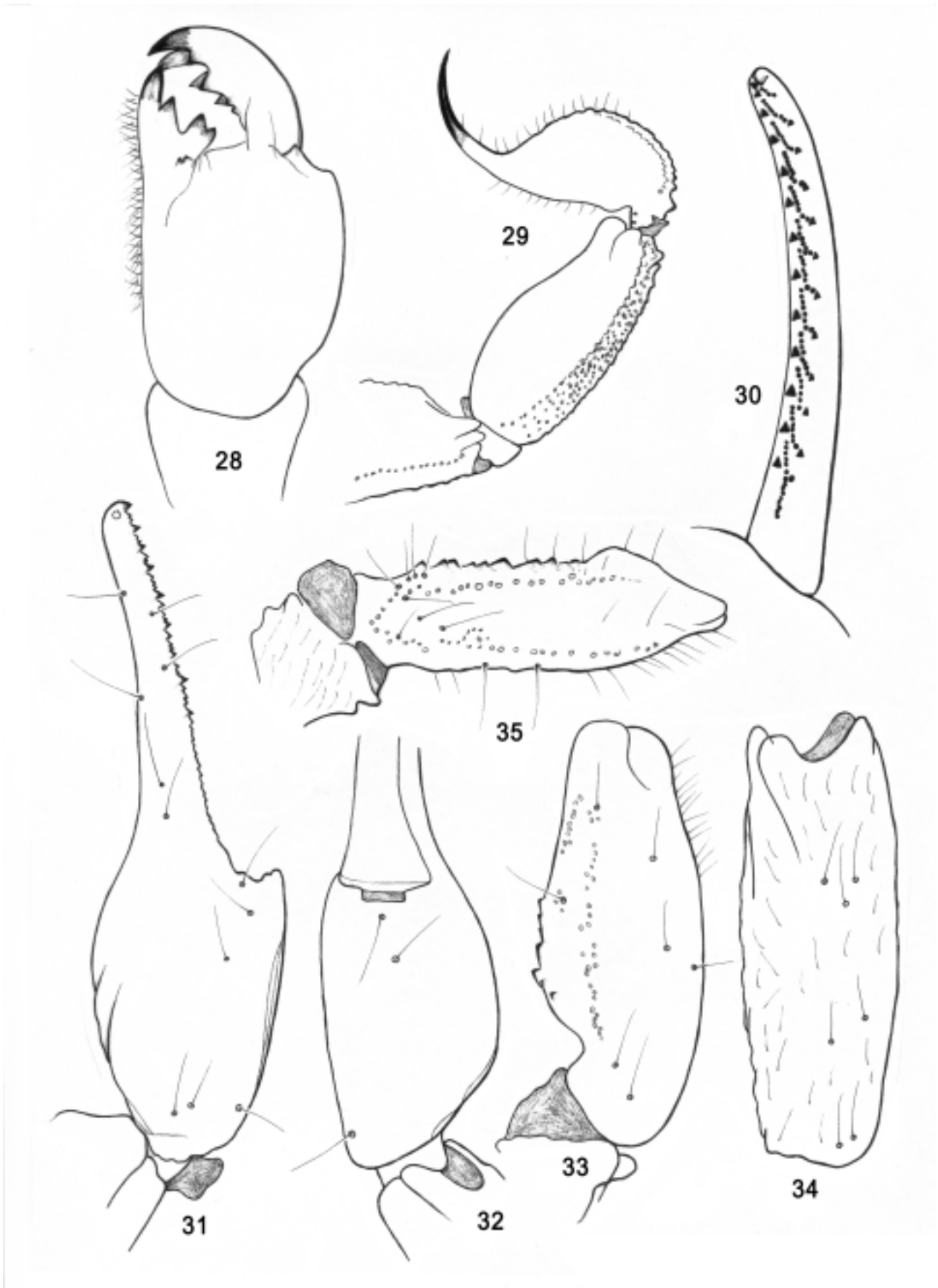
Relationships: The general morphology and pigmentation pattern of the new species shows it to be close to the *Grosphus limbatus/G. bistriatus* group. This group of species is largely distributed in the South-western and central regions of Madagascar. The closest related species however, remains *Grosphus bistriatus* Kraepelin 1900 described from the region of Tulear (see biogeographic section). Both species can be readily distinguished by the following characters: (i) the new species shows a global larger size, with distinct morphometric values (ii) a much paler coloration in the new species with only inconspicuous spots on body and appendages (iii) carinae and granulations are less marked in the new species (iv) anterior margin of carapace is emarginated in the new species but straight in *G. bistriatus*.

Description based on female holotype. Morphometric values following the description. Coloration. Overall yellow to pale yellow without any conspicuous spots on the body and appendages. Prosoma: carapace yellow with only the eyes surrounded by black pigment. Mesosoma yellow, with inconspicuous pale brown zones on the posterior edges of tergites. Metasomal segments I to V yellowish with some blackish zones on the carinae, better markes on segments IV-V. Telson pale yellow without spots; aculeus reddish, darker on tip. Venter: coxapophysis, sternum, genital operculum pectines and sternites yellow to pale yellow. Chelicerae yellow without any variegated pigmentation; fingers with reddish teeth. Pedipalps yellow with rows of granules on chela fingers reddish. Legs pale yellow with some infuscations on carinae.

Morphology. Carapace weakly to moderately granular; anterior margin with a moderate emargination. All carinae weak; furrows moderately developed. Median ocular tubercle anterior to the centre of the carapace; median eyes separated by a little more than one ocular diameter. Three pairs of lateral eyes. Sternum sub-triangular in shape. Mesosomal tergites with thin granulations. Median carina moderately to weakly marked in all tergites. Tergite VII pentacarinate. Venter: genital operculum consisting of two subtriangular plates. Pectines: pectinal teeth count 25-25; basal middle lamellae of each pecten strongly dilated but moderately elongated and covering only the most proximal tooth. Sternites smooth, with elongated stigmata; VII with vestigial carinae. Metasoma: segments I and II with 10 carinae, moderately crenulate. Segments III and IV with 8 carinae, moderately crenulate. Segment V with 5 carinae. Dorsal carinae on segments II to IV without posterior spinoid granules. Intercarinal spaces moderately to weakly granular. Telson with a moderate to weak granulation over



Figures 26–27. *Grosphus sabineae* sp. n. Female holotype. Habitus, dorsal and ventral aspects.



Figures 28–35. *Grosphus sabineae* sp. n. Female holotype.
Figure 28. Chelicera, dorsal aspect.
Figure 29. Metasomal segment V and telson, lateral aspect.
Figure 30. Cutting edge of movable finger.
Figures 31–35. Trichobothrial pattern. Figures 31, 32. Chela, dorso-external and ventral aspects. Figures 33, 34. Patella, dorsal and external aspects. Figure 35. Femur, dorsal aspect.

latero-ventral and ventral surfaces; its dorsal surface smooth; aculeus moderately curved and slightly shorter than the vesicle; subaculear tooth absent. Cheliceral dentition characteristic of the family Buthidae (Vachon 1963); two distinct basal teeth present on the movable finger; ventral aspect of both fingers and of manus with dense, long setae. Pedipalps: femur pentacarinate with moderate spinoid carinae; patella with dorsointernal and dorsoexternal carinae and with a few spinoid granules on the internal face; chela without carinae and with the internal face smooth. Fixed and movable fingers with 11-12 oblique rows of granules respectively. Trichobothriotaxy; orthobothriotaxy A-α (Vachon 1974, 1975). Legs: tarsus with numerous short thin setae ventrally. Tibial spurs present on legs III and IV, thin and long; pedal spurs present on legs I to IV, moderate to strong.

Male unknown.

Morphometric values (in mm) of the female holotype of *Grosphus sabineae* sp. n. and for a female topotype of *G. bistriatus*. Total length (including telson), 55.7/42.9. Carapace: length, 5.7/4.6; anterior width, 4.4/3.7; posterior width, 6.9/5.4. Mesosoma length, 16.8/12/1. Metasomal segments. I: length, 4.1/3.2; width, 3.7/3.0; II: length, 4.6/3.6; width, 3.5/2.8; III: length, 4.9/3.9; width, 3.5/2.8; IV: length, 5.6/4.4; width, 3.5/2.7; V: length, 6.8/5.3; width, 3.5/2.7; depth, 2.9/2.5. Telson length, 7.2/5.8. Vesicle: width, 3.1/2.4; depth, 2.7/2.1. Pedipalp: femur length, 4.8/3.9, width, 1.5/1.2; patella length, 5.7/4.6, width, 2.2/1.8; chela length, 8.9/7.6, width, 2.3/1.8, depth, 2.2/1.7; movable finger length, 5.2/4.6.

BIOGEOGRAPHIC CONSIDERATIONS

The species belonging to the genus *Grosphus* are mainly encountered in dry and subarid bioclimates (Cornet 1974) and in two main types of forests, namely the western dry forests and the southwestern dry spiny forest-thickets (Moat and Smith 2007). Four species only occur in humid and subhumid forests; out of the total 27 species recognized nowadays, 23 species (85%) occur in dry forests and/or dry spiny forest-thickets (Figure 36, Table 1). The second scorpion clade with a high species richness in Mada-

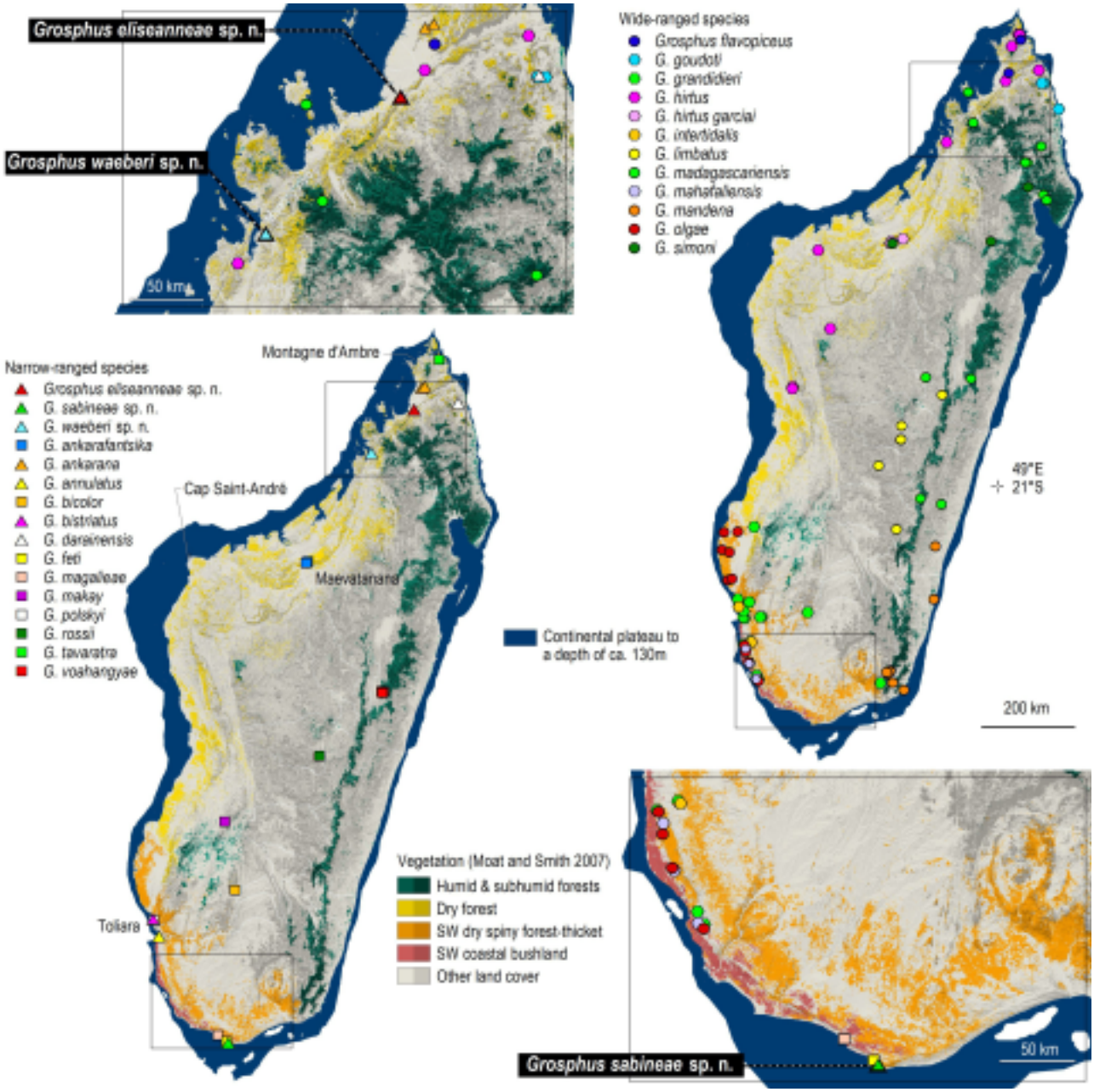


Figure 36. Distribution of the 27 species known in the genus *Grosphus* according to forest cover.

Table 1. Scorpion genera endemic to Madagascar with the number of species occurring in the humid and dry biomes, total number of species within each genus, and family, and number of samples available in our database. (fossil taxa are not included; see Wilmé et al. 2012 for Noe4D).

	Humid	Dry	Total	Doc. in Noe4D
Buthidae				
Grosphus	7	23	27	152
Neogrosphus	1	2	3	12
Pseudouroplectes		5	5	16
Tityobuthus	15	5	19	34
Troglotityobuthus		1	1	1
Sub total Buthidae	23	36	55	215
Microcharmidae				
Neoprotobuthus	1		1	1
⊠*icrocharmus*	8	6	14	33
Sub total				
Microcharmidae	9	6	15	34
Heteroscorpionidae				
⊠*eteroscorpion*	3	3	6	8
Hormuridae				
Opisthacanthus	3	7	10	44
Palaeocheloctonus		2	2	7
Sub total Hormuridae	3	9	12	51
Totals	38	54	88	308

gascar is *Tityobuthus Pocock* 1893, with 19 species described. The majority of the species of *Tityobuthus* occur in the humid and subhumid, i.e., 15 species out of 19 (79%) and only 5 species (26%) are known from dry biomes (Lourenço et al. 2016a, Table 1).

Grosphus eliseanneae sp. n. and *G. waeberi* sp. n. occur in dry forests of the northwest, and are currently only known from their type locality (Figure 36). They occur in two distinct centers of endemism, respectively in the Ankify and Ampasindava centers of endemism (Wilmé et al. 2006, 2012) bordering the Sambirano belt with its humid and subhumid forests extending towards the west coast in Northern Madagascar. The Sambirano has been shown to act as a dispersal barrier for other clades of scorpions, allowing for speciation on both sides over time (e.g., Lourenço et al. 2015c, 2016b). *G. eliseanneae* sp. n. and *G. waeberi* sp. n. seem to be one more case of allopatric speciation in Northern Madagascar from an ancestral population, another typical case complying with the *Neogrosphus* rule (Lourenço et al. 2015c, 2016b). According to this rule, in a changing environment, a high species richness is linked to a great niche breadth of the ancestor taxon of the group (Lourenço et al. 2015c, 2016b: Table 1). The type localities for these two new species are at distances of 25 to 30 km from collection localities of the wide-ranged *G. hirtus* Kraepelin 1901, which is also a dry forest species.

The distance between *Grosphus eliseanneae* sp. n. and the known localities where *G. ankarafantsika* has been sampled is at least 400 km, and the distance between the type locality of *G. waeberi* sp. n. and southwestern Madagascar where *G. bistriatus* has been recorded (Figure 36) is above 1,000 km. Contrary to the humiculous scorpions in the genus *Tityobuthus*, conducting inventories to document the scorpion fauna in the genus *Grosphus* does not rely on specialized techniques such as the Winkler traps, and *Grosphus* spp. are usually sampled by overturning rocks. The 27 species of *Grosphus* are currently documented with more than 150 samples, while only 34 samples document the 19 species of *Tityobuthus* in the Noe4D database. Although the documentation of the *Grosphus* species is far from complete, it is still the best sampled group amongst the endemic scorpions of Madagascar (Table 1, Wilmé et al. 2012). The paucity of inventories to document the range of the *Grosphus* species is therefore not justified to explain the wide gap of more than 1,000 km between the type locality of *G. waeberi* sp. n. and the distribution in southwestern Madagascar of its closest relative *G. bistriatus*.

A possible explanation of such disjoint distributions are of two kinds: (i) a passive rafting of an ancestral population by means of wooden debris or a raft of vegetation, similar to the sweepstake model proposed for the colonisation of the mammals of Madagascar (Simpson 1940, Stankiewicz et al. 2006); or (ii) populations of both species have disappeared from the historical range, such as in the case of rising sea level over the continental plateau after periods of low sea level stand, or more recently due to anthropological deforestation.

In the first scenario, a fertile female or a pair belonging to the common ancestral population of *Grosphus waeberi* sp. n. and *G. bistriatus* could have been passively transported along the western coast of the island. The type locality of *G. waeberi* sp. n. lies at a short distance from the bank of the lower portion of the Manongarivo River, near its estuary in the Bay of Sahamalaza, and *G. bistriatus* is encountered at a short distance from the ocean in the southwest (Figure 36). The mode of reproduction of the scor-

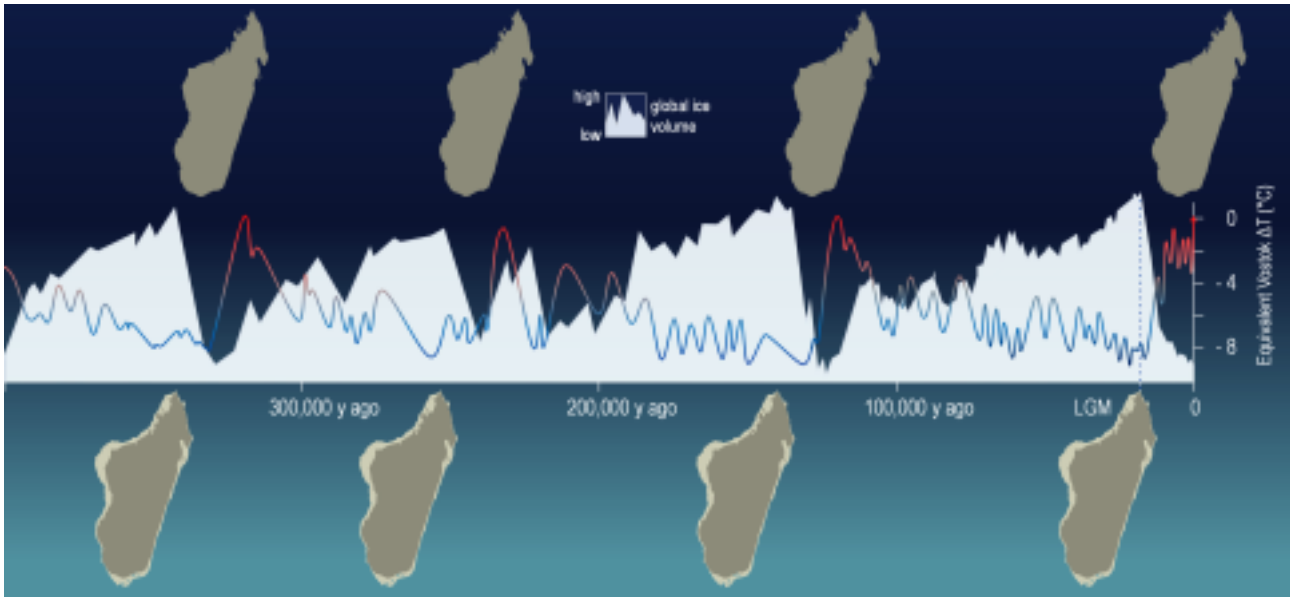


Figure 37. Last glacial/interglacial cycles of the Quaternary with changes in the global ice volume, and temperatures. During cold and dry phases, sea level were some 90 to 130 m below current level and Madagascar had a larger area including the continental plateau (bottom maps).

pions is viviparous, with the development of the embryo inside the body of the female. In the genus *Grosphus*, the gestation can last three to six months (Lourenço and Cloudsley-Thompson 1998, Lourenço and Goodman 2006) and allow a fertile female to settle a new population after passive drifting and landing on new land. The ocean currents along the western continental plateau of the island are variable, and eddies are also known to regularly occur (Heileman et al. 2009). Passive rafting from Madagascar has also been proposed to explain the occurrence of *G. mayottensis* on Mayotte (Lourenço and Goodman 2009). The Indian Ocean South Equatorial Current (SEC) bifurcates into two branches along the east coast of Madagascar; the northward branch feeds into the North Madagascar Current (NMC), which turns at the northern cape of the island and continues westward toward the east coast of Africa over the islands of the Comoros (e.g., Swallow et al. 1988). The ocean currents over the western continental plateau are not as fast and not as straight as the current fed by the SEC and NMC, but the passive rafting along the coast of an ancestral population can be considered because (i) of the absence of a population of these species between these localities distant of more than 1000 km, (ii) the known distribution localities of two sister species *G. waeberi* sp. n. and *G. bistriatus* lie near the coast, at distances < 5 km, and (iii) a female *Grosphus* can protect her offspring in her body during extended periods of times.

The climatic change scenario is best explained in the context of the Quaternary comparatively rapid climate shifts that occurred during the last 2.6 million years. During the cold and dry phases, more of Earth's water was stored as ice, sea level was therefore lower, and forests were receding; during warmer and more humid phases, ice was melting, sea level rose again and forests expanded. For instance, during the last glacial maximum (LGM) some 20,000 years ago, the climate in Madagascar was a lot drier than today, and sea level was at ca. 130m below the current level (e.g., Mercier and Wilmé 2013, Lambeck et al. 2014, Figure 36). The ancestral populations of the nowadays *Grosphus ankarafantsika*, *G. bistratus*, *G. eliseanneae* sp. n. and *G. waeberi* sp. n. could have been distributed over the continental plateau in ancient times, not necessarily during LGM, but during any cold and dry phase of the paleoclimate oscillations (Figure 37) when sea levels were 90 to 130 m below current levels. These paleoclimate oscillations had profound effects, not only on the geomorphology of entire landforms, but also on biological evolution and extinction (e.g., Blois et al. 2013). The continental plateau in the region of Cap Sainte-André in the northwest of Madagascar spans over a distance of some 90 km, and could have harbored populations of *Grosphus* during one or more dry phases of the paleoclimate oscillations. This northwestern portion of the island could have been one of the driest regions, especially the coastal areas where river flow was certainly interrupted during the dry phases of the paleoclimate oscillations (Mercier and Wilmé 2013).

Adaptation to dry biomes is fairly recent amongst scorpions, especially to deserts (e.g., Lourenço et al. 2016a). The families of scorpions represented in Madagascar belong to archaic lineages, but the genus *Grosphus* has clearly adapted to dry biomes, as shown by the limited number of species currently restricted to humid forests (4 species, i.e., 18%), amongst which only one, *G. voahangyae* Lourenço and Wilmé 2015, has a narrow range and seems to be adapted to an extremely peculiar setting (Lourenço and Wilmé 2015b).

Several species of *Grosphus* are narrow-ranged, as is the case in other groups of scorpions occurring in Madagascar. This can be a bias of the paucity of inventories, especially in the dry forests (Waeber et al. 2015). In the case of a species occurring along or near the coast, the current narrow range could be a recent contraction of a once wider occurrence (scenario 2). During the dry phases of the paleoclimate oscillations, sea level was below the current level; for instance, it was at ca. 130 m below that of present-day during the last glacial maximum, some 20,000 years ago (Lambeck et al. 2014, Figure 36). Some species of scorpions may have had a wider distribution over the today submerged continental plateau, resulting in a narrow coastal narrow range nowadays. Such historical wider ranges may have existed for *G. eliseanneae* sp. n. and *G. waeberi* sp. n., but also for *G. bistriatus* Kraepelin 1901, *G. polskyi* Lourenço, Qi and Goodman 2007, *G. annulatus* Fage 1929, *G. magalieae* Lourenço 2014, and *G. sabineae* sp. n.

Grosphus sabineae sp. n. is the 7th species reported from Cap Sainte-Marie. Cap Sainte-Marie is a small reserve with a total area of only 1750 ha, covered with a short dry spiny thicket at an elevation ranging from 110 m to 180 m near the lighthouse. The other six species of scorpions occurring in the reserve of Cap Sainte-Marie are: *G. feti* Lourenço 1996, *Neogrosphus griveaudi* (Vachon 1969), *Pseudouroplectes betschi* Lourenço 1995, *P. pidgeoni* Lourenço and Goodman 1999, *Tityobuthus* cf. *petrae* Lourenço 1996, and *Opisthacanthus lucienneae* Lourenço and Goodman 2006. The reserve is not amongst the key areas for the richness of its vertebrate biodiversity for instance (Goodman and Wilmé 2008). The vegetation is growing with the typical habitus encountered in places with regular and strong winds, and the trees, growing in sand, are extremely short. Cap Sainte-Marie is also known to host at least three species of diplopodes, *Zoosphaerium haackeri* Wesener 2009, *Z. libidinosum* (de Saussure and Zehnter 1897) and *Riotintobolus anomalus* Wesener, Enghoff and Sierwald 2009 (Wesener 2009, Wesener et al. 2009). It is not yet known why and how the setting at Cap Sainte-Marie is favourable for these scorpions and possibly other invertebrates, but this small reserve at the southern tip of Madagascar certainly deserves further studies, as well as full protection.

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ARTICLE

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Which form of agreement works for community-based management? A case study from southwestern Madagascar

Katinka Thielsen[I]

Correspondence:
Katinka Thielsen
Ernst Moritz Arndt-Universität Greifswald, Institut of Geography
17489 Greifswald, Germany
Email: katinka.thielsen@staff.uni-marburg.de

ABSTRACT

Aware that humans and nature are inseparably linked many organisations in Madagascar support the community-based natural resource management approach to promote the international policy of biodiversity conservation and protection. In this context, community associations have been introduced to transfer management and use rights for natural resources to the local population. However, the fast, donor-driven top-down procedure of establishing new rules contradicts the local rhythm and handling of rules. Against this background, this paper focuses on the ethnic group Tanalana and explores key actors and locally initiated rules and agreements, analyses their level of effectiveness and discusses their possible application for community-based natural resource management in the buffer zone of Tsimanampesotse National Park in southwestern Madagascar. The paper looks at an example of rule negotiation outside the community-based management context concerning the use of a key resource in raising livestock. The example demonstrates that, on the one hand, the overlapping memberships in different social and kinship groups, and on the other hand, different individual economic interests can hinder successful collective action for natural resource management. Moreover, this example shows that already existing or newly introduced rules can be further called into question and are variously interpreted depending on the context. The degree of sanctions depends on several factors: (i) frequency of transgression, (ii) amount of affected persons, (iii) social relationships between the concerned parties and (iiii) social and communicative behaviour of the transgressor (in the past and present). This study finds that rules serve as rough guidelines, as a basis for discussion in cases of transgression, but do not function as fixed prescriptions. The data for this study was collected through semi-structured interviews and participative observation in six *fokontany* (village and related hamlets) to the east and west of Tsimanampesotse National Park.

RÉSUMÉ

Dans le contexte de la protection et de la conservation de la biodiversité, de nombreuses organisations de développement appuient la création d'organismes et la formulation de réglementations en vue d'une gestion durable des ressources naturelles autour des aires protégées de Madagascar. Dans la zone tampon du Parc National Tsimanampesotse, des transferts des droits d'usage et de gestion des ressources naturelles d'un territoire précis à la population locale, suivant l'approche de *community-based management*, ont été réalisés. Dans la mesure où la population rurale dépend étroitement des ressources naturelles, la nécessité de son intégration participative dans le processus de la protection est évidente. L'objectif premier d'instaurer de nouvelles règles sur les structures locales préexistantes était rarement réalisable à cause de la rapidité de l'élaboration des contrats de transfert de gestion. La présente recherche se concentre sur le groupe ethnique Tanalana, en tant que plus grand groupe de cette région et principal utilisateur des ressources naturelles du territoire du Parc National Tsimanampesotse, dans la région Atsimo Andrefana dans le Sud-ouest de Madagascar. Les acteurs clés et la négociation des règles locales sont ici exposés pour analyser leur domaine d'action et discuter leur applicabilité dans le contexte du *community-based natural resource management*. L'exemple d'un processus de négociation pour la gestion d'une ressource clé pour l'élevage hors du contexte de *community-based management* montre les différents facteurs qui compliquent une action collective à succès pour la gestion des ressources naturelles : d'un côté une personne est simultanément membre des différent groupes sociaux et parentaux qui déterminent des droits et obligations pour l'utilisation des ressources et de l'autre côté les individus ont des intérêts économiques différents qui, selon leur position sociale, influencent les décisions collectives. En outre, cet exemple montre que les règles existantes ou nouvellement mises en place peuvent être remises en question et interprétées différemment selon le contexte. L'étude de cas a été menée de manière qualitative dans six *fokon-*

I Ernst Moritz Arndt-Universität Greifswald, Institut of Geography, 17489 Greifswald, Germany

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tany à l'ouest, vers le littoral, et à l'est sur le plateau du Parc National dans la commune de Beheloke, via des interviews semi-structurées des divers acteurs individuels et collectifs. Les membres de cette société agro-pastorale, se déployant des deux côtés du Parc, sont liés à travers une même origine, le mouvement bidirectionnel de la transhumance et le commerce. Pour mieux comprendre l'interaction sociale et le processus de négociation des intérêts dans la gestion des ressources, nous avons également mené une observation participative à plusieurs réunions et activités quotidiennes.

INTRODUCTION

Madagascar's status as a 'biodiversity hotspot' (Myers et al. 2000) attracted the World Bank and international conservation groups in 1988 to technically and financially support the Malagasy Government for the elaboration of the National Environmental Action Plan (NEAP), carried out in three phases from 1990–2008 (Hanson 2012). The plan aims to find solutions for Madagascar's environmental problems such as deforestation, loss of biodiversity, erosion and soil degradation (Mercier 2006). The main objectives of the first phase (1990–1997) were the establishment of an institutional infrastructure for conservation activities in already existing and newly established protected areas, and the promotion of Integrated Conservation Development Projects (ICDP), which aimed to provide alternative income possibilities to resource use for local people living in the peripheral zones of protected areas (Marcus and Kull 1999, Raik 2007, Hanson 2012). The donor-driven ICDP approach did not meet local needs because of its standardized and inflexible character. It failed to improve the economic conditions for the local population and consequently did not manage to exclude humans from resource use in protected areas (Marcus and Kull 1999, Raik 2007, Pollini 2011, Hanson 2012, Waeber et al. 2016).

During the second phase of the NEAP (1997–2002) the focus was on the implementation of a new, participatory bottom-up management approach, community-based management (CBM). Two laws were enacted in Madagascar aimed at decentralising government control over natural resources, both of which enabled a contractual transfer of management rights of natural resources to the local population: the GELOSE-law (*Gestion Locale Sécurisée*) of 1996 applies to forest, pasture, wildlife and water; the GCF-law (*Gestion Contractuelle des Forêts*) of 2001 specifies the management of forest resources and facilitates the administrative procedure (Antona et al. 2004). With strong support from non-governmental organisations (NGOs), about 1200 voluntary user associations- named COBAs (*Communauté de base*)—were founded in the 22 regions of Madagascar (Bertrand et al. 2014) to develop their own rules and sanctions for natural resource use and to control compliance in the transferred areas (Kull 2002). The extendable three-year COBA contracts determine the time period and amount of resource use to be regulated; for resource users, a fee-based authorisation is required from the association's executive board.

Several authors have observed the CBM movement in various regions of Madagascar and have identified many problems, questioning the compatibility with local social structures (Blanc-Pamard and Fauroux 2004, Goedefroit 2006, Fritz-Vietta et al. 2009, Bérard 2011, Pollini 2011, Pollini et al. 2014). Many researchers criticise development agencies' "race of contracts" (Bérard 2011), which very often causes a 'one-size-fits-all' approach resulting in a lack of participation by local people (Pollini et al. 2014). Instead of supporting entire local communities in the development of their own rules (bottom up), 'stereotyped rules' are introduced in artificially created entities that represent only one part of the whole user community (top down) (Blanc-Pamard and Fauroux 2004, Bérard 2011, Pollini 2011). For local populations, access to natural resources is determined by historically grown relationships; the dynamic social rules and norms structure the communication and interaction between individuals and groups (Fritz-Vietta et al. 2011). Each ethnic group has to be studied in its own context to understand all the dynamics in detail. The present study hence focuses on one ethnic group, the Tanalana, exploring their rules and procedures in decision making to discuss their applicability in the CBM context.

Many authors have investigated local rules in the context of natural resource management at different places in Madagascar (Horning 2000, Kull 2002, Horning 2003a, b, 2004, Muttenzer 2006, 2010, Bérard 2011 but this paper is the first to focus on the ethnic group Tanalana living in southwest Madagascar. Horning (2003a, b) and Muttenzer (2006, 2010) point out that it is important to consider customary rules as syncretic constructs of different historical moments, not as timeless and fixed entities. Bérard (2009 and 2011) confirms this statement by demonstrating that customary rules are adaptable to the situation and are in a constant state of change. In a context of legal pluralism, researchers regularly wonder about the (in)stability of local and formal rules and try to identify the factors of (non-)compliance (Horning 2000, 2003a, b). Horning (2000), Kull (2002) and Gardner et al. (2008) conclude that local rules under certain circumstances can be more effective and sustainable for natural resource management than formal rules introduced by the state or those supported by conservation agencies. This study contributes to this discussion by demonstrating the procedures of establishing and handling rules and pacts among the Tanalana in southwestern Madagascar and testing their applicability as a basis for the CBM approach.

After presenting the study area and the methodology, this paper describes Tanalana society. Key actors and procedures for decision making are outlined in order to understand the negotiation of rules for resource management, especially for a fodder plant. Finally, the importance of these findings is discussed in the context of the CBM approach.

STUDY AREA

Tsimanampesotse National Park (literally "sea/lake without dolphins") was originally founded as the *Réserve Naturelle Intégrale* in 1927 with 17,520 ha in southwestern Madagascar. This area was expanded to 43,200 ha by 1966 and became a National Park in 2002. The third phase of the NEAP, started in 2003, was inspired by the 'Durban Vision' of president Ravalomanana, who decided in the course of the Fifth World Parks Congress in South Africa in to expand Madagascar's protected area (marine and terrestrial) from 1.7 (3%) to 6 million ha (10% of the total surface) by 2012 (Freudenberger 2010). In this context, Tsimanampesotse National Park's area was quintupled between 2005 and 2007 from 43,200 to 203,744 ha. The whole area of the park currently extends from the Onilahy River in the north to the Menarandra River in the south and affects six rural communes (Beheloke, Itampolo, Androka, Ampanihy, Ejeda and Beahitse) in two districts (Tuléar II and Ampanihy West) in the region Atsimo Andrefana. The Park is part of the geographic region the Mahafaly Plateau, which is com-

posed of a coastal zone along the Mozambique Channel in the west and a limestone plateau in the east. The study area encloses six *fokontany* (smallest deconcentrated administrative unit, composed of one or more villages and their related hamlets) in the rural commune Beheloke (District Tuléar II) in the north of Tsimanampesotse National Park (Figure 1).

The buffer zone of the whole park consists of 31 community-based management areas, each managed by a COBA (*Communautés de Bases*) (cf. Waeber et al. 2015) (Figure 1). Four organisations support the establishment of COBA contracts, which are mainly based on GCF law, and accompany the resource management activities in the transferred areas: the NGOs Tany Meva Foundation and World Wide Fund for Nature (WWF), the German federal agency GIZ, and the (semi) state agency Madagascar National Parks (MNP), which is also responsible for the management of the National Park.

While the associations of the buffer zone establish their own rules (*dina* GELOSE or *dina* COBA), the management of the National Park is based on the national legislation COAP (*Code des Aires protégés*) and a supplementary park-specific rule system controlled by MNP. The forest area outside the protected areas is also under the jurisdiction of the State (Supplementary Material). Countrywide, MNP rangers and forest state agents (*chef de cantonnement forestier*) govern extensive areas, receive low salary and do not have enough equipment to fulfil their tasks in an effective manner (Bertrand et al. 2014, Cullmann 2015). Consequently, access to forest products is 'quasi free' for the local population; yet this is far from a 'free rider' concept as access to land and natural resources is organised by customary rules (Goedefroit 2006).

The ethnic group Tanalana are the main inhabitants of the northern periphery of the National Park. The Tanalana are categorized in the official administrative terminology as 'Mahafaly,' one of eighteen ethnic group identities introduced by the French colonial rulers and adopted thereafter by the Malagasy government, researchers and NGOs (Larson 1996). This designation encompasses all ethnic groups living to the south of the Onilahy River on the Mahafaly Plateau and does not take account of the ethnic heterogeneity in this area (Eggert 1981). Interviewees perceive themselves as Tanalana ("inhabitants of the coastal plain"), historically originating from the Androy and Anosy region in southern Madagascar. They distinguish themselves from other Mahafaly groups. At the end of the 15th century, the Tanalana first settled in the littoral of the Mozambique Channel before they went on to populate the limestone plateau in the east, where they found better conditions for agriculture and raising livestock during the dry season (Esoavelomandroso 1989). Currently living on both sides of Tsimanampesotse National Park (Figure 1), members of this agro-pastoral society are closely connected by a common origin (lineage and clan affiliation) and through social interactions such as rituals, transhumance movement in both directions, and commerce. The Tanalana live in a semi-arid area where they mainly practice subsistence agriculture and animal husbandry and are highly dependent on the exploitation of natural resources (e.g., fuel wood, construction material, fodder plants for livestock, medicinal plants).

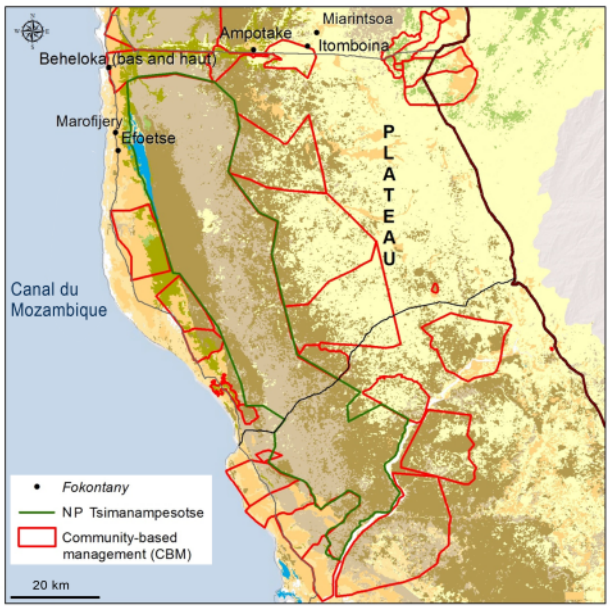

Figure 1. Tsimanampesotse National Park, community-based management areas and study sites *fokontany*. (Source SuLaMa, LandSat 2006)

While the Tanalana are the main users of natural resources in the study area, there are two other user groups living in the vicinity of Tsimanampesotse National Park. The Vezo Sara comprises various groups from the north settled along the shoreline, who mainly practice fishing (for a discussion of Vezo identity see Astuti 1995); the Mahafaly are composed of different groups in the east of the limestone plateau, who like the Tanalana, mainly practice agriculture and animal husbandry. Inter-ethnic marriage and flexible adoption of activities, originally linked to the other ethnic group, connect these groups. For example, two decades ago many of the Tanalana, especially those who are not in contact with livestock, started to also practice fishing (mainly without a pirogue), while Vezo also work the land and accumulate small ruminants. Nevertheless, social rules differ amongst the three groups (taboos, performance and manner of rituals). The sense of belonging for the Tanalana is shaped by the agro-pastoralism lifestyle (e.g., Poyer and Kelly 2000), their social rules and the self-allocation to a clan chieftaincy, whose foundation can ideologically be traced to the founding fathers of the Tanalana.

METHODOLOGY

The data was collected in two phases through diverse qualitative research techniques. First, the SuLaMa (Sustainable Landmanagement in southwestern Madagascar) project team of Malagasy and German researchers conducted an interdisciplinary (agronomy, biology, forestry, ecology, anthropology) exploratory case study. By applying semi-structured interviews and group discussions, the aim was to identify different collective and individual actors on the local and regional levels and to gain insight on social structures and local perspectives of resource use. I use the term 'local' to describe the family, lineage, clan, *fokontany* and commune level, the last being in a maximum distance of eight hours by feet for all the inhabitants of the commune Beheloke. This first study was conducted in four *fokontany* east and west of the National Park, in Efoetse (E 043° 41' 54.8", S 24° 04' 42.4"), Marofijery (E 043° 42'0", S 24° 02' 0"), Itomboina (E 044° 05' 10.9", S 23° 51' 59.2") and Miarintsoa (E 044° 06' 17.7", S 23° 50' 14.2"), each for the duration of one week in 2011 (SuLaMa 2011). The *fokontany* were selected applying the following criteria: (i) membership in the rural commune Beheloke (2004: 13,117 inhabitants) (Commune de Beheloke 2005) and (ii) participation in one of the management systems of the National Park (co-management of the Park and/or CBM of the buffer zone).

For the second phase, an extended case study approach was chosen (sensu Yin 2003) to assess the perspectives of the local individuals and collective actors and to understand their social interactions in the process of interest negotiations concerning natural resource use. In collaboration with two research assistants, in-depth data collection was carried out for six non-consecutive months from 2011–2014 in three *fokontany* in the littoral, Beheloke Haut (E 043° 40′ 16.5″, S 23° 54′ 33.5″), Marofijery and Efoetse, and three *fokontany* on the plateau, Ampotake (E 043° 58′ 36.6″, S 23° 52′ 27.8″), Itomboina and Miarintsoa. The four *fokontany* from the first study were chosen and two more were added that were identified as important during the first research phase: Beheloke Haut is the administrative centre of the rural commune and the seat of a clan chief, and Ampotake has the COBA association governing the largest forest area located in the north outside the National Park (Figure 1).

The main research method for gathering information for this study was the semi-structured interview. With the help of Malagasy-French speaking assistants, interviews were conducted with 125 local people, 94 men and 31 women aged 15 to 80 years from different clans and lineages of the Tanalana, who are the main users of natural resources in the study area. These included persons with traditional (lineages elders including chiefs) or administrative (*chef de fokontany*, mayor and the corresponding deputies and assistants) power, who are relevant for decision making over natural resource use and other members of the society, who practice different natural resource-dependent activities such as agriculture, pastoralism, household, carpentry. Additionally, we interviewed eleven conservation practitioners from NGOs and (inter-)national agencies (Tany Mena, WWF, MNP, GIZ). Relevant actors for interviews were identified through information from other actors by performing a bottom-up driven snowball approach (Atkinson and Flint 2004).

During the interviews, questions focused first on the social context (e.g., lineage/clan affiliation, legitimation) and daily livelihood activities of the interviewees, then on their implication in decision making for natural resource management, their perception of (in)formal rules and their interaction with external actors. Supplementary group discussions facilitated observations of negotiation processes amongst actors. This method was combined with participatory mapping with individuals and groups, for example social and resource maps (Narayanasamy 2009). These tools help to understand the distribution of ethnic groups, clans and lineages in populated areas and to gain an insight into their perception of property of land and natural resources (private and common). Through participatory and systematic observation (e.g., (ir)regular meetings, daily activities, rituals) it was possible to identify new actors relevant for the research and to understand their relationship.

To validate the collected information, the same questions were repeated with different persons in different places and time (data triangulation); close cooperation was carried out with Malagasy colleagues doing research in related domains in the same area (investigator triangulation), and different methods were applied for data collection such as interviews, observation, participatory techniques (methodological triangulation) (Denzin 1970). Data analysis was realised with the computer-supported program Atlas.ti, which facilitated the treatment of the transcribed audio files and the code-based elaboration of theory (Smit 2002).

RESULTS

TANALANA ACTORS AND DECISION MAKING. Tanalana society consists of three clans (*raza*)—*Tevondrone*, *Temitongoa*/*Tetsivalea* and *Temilahehe*—subdivided into several lineages (*famosora*), each headed by a traditional chief. While clan members refer to a supposedly historical founding ancestor to whom they do not necessarily trace genealogical links, the people of a lineage refer to a common real nameable consanguineous ancestor. The clan and lineage chiefs (*mpitan-kazomanga lava* and *mpitan-kazomanga fohe*, respectively) are chosen by criteria of genealogy and age; they are responsible for performing rituals to maintain the balance of the human and the supernatural world. They are a moral, symbolic, honorific or divine authority enforced through their direct relationship to the traditional creator (*Zanahary*) and the ancestors (*raza*). The traditional chiefs are advised by other elders (*olobe*/*roandria*) who are the main actors responsible for decision making and conflict resolution in Tanalana society. These elders, consisting of several persons of the main lineages, have significant influence on the placement of persons in administrative (*chef de fokontany*, mayor) and traditional (clan and lineage chiefs) positions (Figure 2). Although gerontocracy and genealogy predetermine the succession of the chief positions, the elders can exclude the suggested candidate if he is assessed as unworthy because of unsocial behaviour or a lack of social recognition. The foundation of a clan or lineage is linked to the establishment of a holy pale (a wooden construct of different pieces, called a *hazomanga*), the forging of a holy knife (*vy lava*) and the enthronization of a traditional chief. It is possible for the post of traditional chief to be vacant for years or decades, the elders managing the lineage or clan without a spiritual head. The traditional chiefs are assumed to possess historical knowledge about rules and structures in society because of their age and position, whereas their capacities and abilities are often limited by their age and physical condition. There are exceptional cases of charismatic chief personalities who have the authority to convene meetings and who are consulted in conflict cases but they are always surrounded by other influential elders.

TANALANA RULES AND PACTS. The social cohabitation of the Tanalana is structured by the *lilin-draza* (rules of the ancestors), which describe the totality of all rules and codes of conduct in Tanalana society. The *lilin-draza* were established by the ancestors at an unknown point in time and are transmitted from generation to generation. These rules are in the 'collective knowledge' (Halbwachs 1967) and often cannot be linked to a concrete date or person.

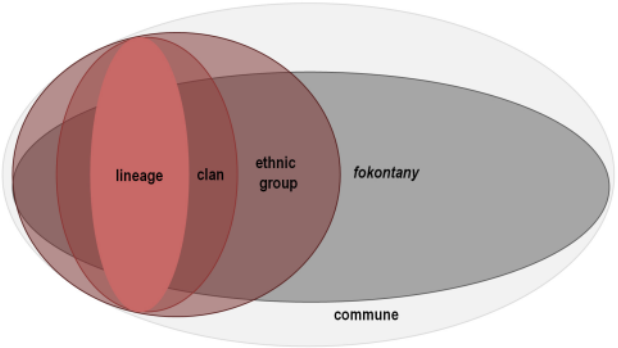

Figure 2. Overlapping levels: (i) administrative levels: *fokontany*, commune and (ii) social levels: lineage, clan, ethnic group.

BOX 1. *FOKONOLONA*. Contrasting the official administrative definition of *fokonolona*, "all inhabitants of a *fokontany*" (Decreed N. 2004-299, 3.3.2004) and the original meaning, "members of one clan/lineage", (*foko* = clan/lineage; *olo* = people/human being), it is obvious that this term needs a closer inspection (cf. Pollini and Lassoie 2011 for details). What the Tanalana mean by *fokonolo* (local term for *fokonolona*) depends on the context. Both the traditional chief and the *chef de fokontany* can convene *fokonolona* ('community') meetings for decision making and conflict resolution. When the Tanalana talk about a meeting convened by the traditional chief or the elders, *fokonolo* means representatives of a lineage or clan living in one or more *fokontany* (inner or trans-*fokontany fokonolo*). When they refer to a *fokonolo* meeting at the *fokontany* level which is convened by the chef de fokontany, it describes a group of people composed of several members of all ethnic groups, clans and lineages (but not all inhabitants) who come together to discuss a problem concerning the *fokontany* territory (*fokontany-fokonolo*). The administrative nomination *fokonolo* includes several *fokonolo*, which can be across *fokontany* boundaries. It has been observed that both *fokonolo* meetings vary considerably from one occasion to another in composition and number. But Tanalana people often say that it was a meeting of the *fokonolo* to underline that "everybody" (of the *fokontany* inhabitants or clan or lineage members) has participated, to reinforce the collective spirit and the importance of the results. Because the number and the persons are not fixed, the most suitable definition for *fokonolo*, given by an elder, is: "all people who meet at this moment to take a decision" (local resident, Beheloke I, 2011, quote 4:3). An important point to stress is that the *fokonolo* meeting is not the arena to make democratic decisions or to openly discuss all the ideas in society. In all meetings observed during the field research, the elders made the decision before or outside the official *fokonolo* meeting (already shown for other regions in Madagascar by Fauroux in 2003, Blanc-Pamard and Fauroux in 2004). (…) "[W]hen we have to make an important decision, (…) only the elders meet and after taking the decision, we convene the *fokonolo*. For this [pre]decision the main lineages of the village meet." (local resident, Ampotake 2013, quote 61:7).

The *lilin-draza* are oral guidelines for the social interaction of the lineages, clans or the entire ethnic group. They describe duties to be accomplished vis-à-vis the supernatural beings (spirits of ancestors, spirits of nature, traditional creator) and other members in society. The Tanalana believe that the land, animals and natural resources are owned by these supernatural beings and only provided to humans for using. This is why the Tanalana perform rituals of demand and gratitude in different contexts of natural resource use, for example when they work the earth or practice *hatsake* (slash and burn cultivation). The *lilin-draza* indicate how and when to practice rituals to honour elders and supernatural beings. "Before you clear the forest, you take a black chicken or a sheep to apologize to the supernatural beings, who are the owners of the forest, so that nothing will happen during the clearing process and we are not blessed by the machete (…)." (local resident, Ampotake 2013, quote 40:45).

The *lilin-draza* also designate what is private property, e.g., fenced fields, livestock pens and houses. The land is property of the respective clan or lineage. This lineage land is provided to families or individuals. The forest area and the pasture area outside the agricultural fields is common property, of the trans-*fokontany* boundary *fokonolo*, and also accessible for other users with or without kinship or direct social relations. These areas are used as pasture, as well as providing a source for the collection of alimentary and medicinal plants, firewood and construction materials; they are also used for hunting and ritual practice.

Taboos (*fady* called *faly* in Tanalana dialect), which are a part of the rules of ancestors (*lilin-draza*), prohibit using certain species of plants and animals or entering or polluting sacred land (*tane faly*) or sacred forest (*ala faly*). Places are faly when spirits of nature or ancestors reside there, or if the holy pale (*hazomanga*) of the traditional chief is planted. These interdictions of conduct have different origins (ancestors, spirits of nature, diviner-healer) and can concern individuals, families, lineages, clans or the entire ethnic group. The place taboos are also binding for outsiders who are not members of the belief system.

The elders and supernatural beings ensure compliance of the *lilin-draza* (including *faly*). If a *lilin-draza* is transgressed, the elders or the supernatural beings can demand that the person concerned perform a purification ritual (*hifikifike*) with a sacrificial animal—a chicken, goat or in serious cases, zebu cattle. Many interviewees reported that supernatural beings express their discomfort with the manner of using natural resources through dreams and by forcing people to apologize through compensation rituals (for other examples in Madagascar, cf. Bidaud Rakotoarivony and Ratrimoarivony 2006). The Tanalana believe that if the transgressor does not follow the advice of the elders and/ or the supernatural beings, he/ she can be condemned to divine sanction (*hakeo*), which results in negative consequences like illness, diminution of goods or a general imbalance between humans and the supernatural world. In cases of rule transgression that concern the well-being of the whole group (e.g., pollution of a spiritual place), the social pressure to perform a ritual is higher than in cases of individual taboo transgression (e.g., ignorance of an alimentary taboo); it can even result in social exclusion by the traditional chief.

When defiance of a *lilin-draza* directly harms another person, family, lineage, clan or the entire ethnic group, the elders discuss the fee that the culprit has to pay in the form of livestock as indemnification. The form and amount of punishment is not fixed but negotiated case by case; sanctions depend on (a) the frequency of transgression, (b) the place of transgression, (c) the amount of affected persons, (d) the social relationship of the transgressor/ culprit and the damaged party, (e) the social status of the transgressor, and (f) his/ her behaviour during the meeting in the past and present. The elders are responsible for weighing the different factors and their effect on the formulation of social and/ or financial sanctions. In our study, we observed that *lilin-draza* serve as a basis for discussion, yet are interpreted differently depending on the context. "(…) [T]here are people in our village who have transgressed taboos: they made their field near the tombs of ancestors, cut ancestral trees that are places for sacrifices and deforested the area around the funeral sites. So we were forced to make a first meeting with the traditional chief (*mpitan-kazo-*

manga) to discuss the situation. So the chief was forced to formulate the sanctions of one goat per person who has transgressed the *lilin-draza*." (local resident, Marofijery 2013, quote 1:1).

Lilin-draza are frequently transgressed. Interviewees offer a diversity of reasons for these transgressions: (a) a lack of kinship leading to feeling unconcerned, (b) poverty and the lack of alternative income possibilities for natural resource use, (c) a change of beliefs from obeying the *hazomanga* (holy pale) and spirits of nature to following Christianity. It is also possible that sacred places lose their *faly* status because the spirit has left the place and the people have stopped practicing rituals. Taboos are only stable when people value the objects and places regularly through sacrifices and prayer. People might not feel concerned by *lilin-draza* if they do not fear the individual moral or material consequences; the majority nevertheless use these rules as reference for conflict-management processes when interacting with other members of Tanalana society. Except for place taboos, the prohibitions are not valid for outsiders of Tanalana society; for example, while the Tanalana stick to the taboo not to hunt and eat the radiated tortoise (*Astrochelys radiata*), they indicate the abode of the animal to other consumers and hunters. The handling of this taboo shows the group specificity and permeability of taboos; it also illustrates that taboos in Madagascar do not automatically serve conservation aims (for a discussion of taboos in the context of conservation in Madagascar, see Walsh 2002, Horning 2003a, 2003b, Tengö et al. 2007, Jones et al. 2008, Keller 2009).

Another form of agreement among the Tanalana is the *titike* (vow or curse). This can be a form of social pact or a sincerity oath, the former action is used as a conflict prevention tool amongst individuals and/ or groups, the latter for identifying culprits. The oath contains maledictions and aims to influence the conscience of the person who has already done and may still do a crime. The Tanalana believe that supernatural beings take responsibility to identify and punish the (potential) culprit. People are connected by a symbolic tie and enter in a common agreement of mutual trust by reducing mistrust. This ritual is performed especially in the context of transhumance as an inner and intra-ethnic moral connection of herders and host communities (littoral and plateau). These pacts are performed by a lineage elder or lineage chief according to demand on the *fokontany* level; they connect the transhumance guests (Tanalana and Mahafaly groups) with the resident Tanalana population. In 2013 it was additionally performed by the clan chiefs concerning the whole ethnic group Tanalana and their related groups.

A third form of rules are *dina* (rules/pacts/social convention), which are established on the *fokontany* or commune level, or in the context of CBM (Supplementary Material). They are formalised in written documentation and legalised on the court level. Bérard (2009) distinguishes 'indigenous *dina*' (traditional oral rules equivalent to the Tanalanas' *lilin-draza*), 'customary *dina*' (formalised rules established during the (post)colonial period) and '*dina* GELOSE' (formalised rules established in the context of CBM). It is not possible to determine the exact moment of origin of an 'indigenous *dina*' in a local society, but researchers agree that the term *dina* was first used in a wider political context during the regime of King Andrianampoinimerina (Condominas 1961, Bérard 2009). The meaning of the term *dina* underwent several changes within Madagascar's history, guided by different aims of control or decentralisation of power (Bérard 2009, Andriamalala and Gardner 2010), and hence the term does not mean the same for the persons living in the Malagasy highlands as it does for the coastal inhabitants. The Tanalana define *dina* as the formalised rules (*fokontany*, commune, CBM) and use the term *lilin-draza* to describe the orally transmitted rules that are blessed by the ancestors. "For the *vazaha* [the state, foreigners or development agencies], they have their *lilin-draza*, which are the *dina*; in turn the traditional society, like ours, we have our *dina*, which are the *lilin-draza*; and every party tries to see which are the most adaptable to their milieu." (local resident, Ampotake 2013, quote 95:3).

COMMUNITY-BASED RESOURCE MANAGEMENT NEAR TSIMANAMPESOTSE NATIONAL PARK. The initial idea of the conservation agencies for the implementation of the CBM was the elaboration of a set of rules (*dina* GELOSE/ GCF or *dina* COBA) based on the already existing local rules (*lilin-draza/faly*) so as to assure that members of the COBA associations identify with the protection of their own natural resources (GELOSE law 96-025, Article 49). However our finding show that the Tanalana have no *lilin-draza*, *faly* or *titike* that clearly determines an amount for natural resource use. There are some taboos prohibiting the use of certain natural resources and certain resources that are considered private property, but they do not focus on sustainable use or equitable distribution. Furthermore *lilin-draza* are sometimes lineage or clan specific: for example, the taboo to hunt the bird *Turnix nigricollis* is not binding for all clans and hence cannot serve as a common basis for CBM.

The operating conservation agencies (WWF, MNP, GIZ and Tany Meva) hence prefer to establish new rules for the CBM but push this procedure through pre-formulated rules and predetermined time schedules. In contrast to the local rhythm and timeline for rule negotiation the new rules are fixed only in about two meetings. Furthermore, promoters of CBM (especially WWF and GIZ) appropriated the concept of taboo concerning the whole ethnic group by naming one of the zones in the transferred area *ala faly* (sacred forest) (cf. Keller 2009). This zone is equivalent to a core zone in the National Park where natural resource use is strictly forbidden by the national law, but it has no reference to local beliefs: "the sacred forest [in the CBM area] is not taboo in the traditional perception (…) it was an order of the WWF" (local resident, Beheloke *haut* 2012, quote 35:3). In the absence of regular ritual practice, the local population does not perceive a place as taboo and continue using natural resources.

The new COBA rules, like the locally established rules, are not perceived as fixed entities and are variously interpreted by the local population (see also Andriamalala and Gardner 2010, Rives et al. 2013). There is even a rule violation that is unofficially institutionalized. Two COBAs on the plateau allow their members to practice slash and burn (*hatsake*) for a small amount of money distributed to the association. Slash and burn is used by the Tanalana for gaining new agricultural fields and bushfires for stimulating fodder plant growth for raising livestock. In the COBA contract, its prohibition follows the (inter-)national conservation paradigm (cf. Scales 2011, 2014, Keller 2008). This contrasts the local perception that land is the guarantor for life and the continuity of mankind (Keller 2008). Disposing enough land for future generations and the multiplication of cattle, who are the highest cultural and economic good, is in the main interest of Tanalana people. Access to ancestral land (*tanin-draza*) through deforestation is very often not refused by the executive board of the COBA if the person has enough manpower to cultivate the land. Furthermore,

social cohesion (*fihavanana*, *filongoa* in local accent) and kinship relations hinder the application of sanctions (for other examples in Madagascar see Andriamalala and Gardner 2010, Fritz-Vietta et al. 2011).

NEGOTIATION OF RULES FOR THE FODDER PLANT *SAMATA*. In contrast to the externally promoted forms of natural resource management previously presented, this section explores an example of local rule negotiation processes. For about three decades now there has been ongoing negotiation processes in some *fokontany* over the use of the fodder plant *samata* (*Euphorbia stenoclada*) (Figure 3). Because this natural resource exists mainly outside the buffer zone, it has not yet been a focus for conservation agencies. Nonetheless, this paper argues that exploring the processes of negotiation surrounding this example can help point the way for the future design of CBM.

This key resource serves to feed livestock (goats, sheep and mainly cattle), which is the economic and cultural basis of Tanalana society (Fauroux 1997). This plant is used in the littoral, especially in the dry season, by livestock herders (Tanalana and Mahafaly) living on the coast and those coming from the plateau for transhumance. Unsustainable cutting practices, declining precipitation, the expansion of agricultural fields, and longer grazing periods of cattle herds from the plateau because of the threat of cattle raiders has reduced the total number of *samata* trees in the littoral (cf. Goetter 2016).

In Tanalana society there are three different given statuses for the property of *samata* trees: (i) *samata* trees in the pastoral land (*monto*) are a common pool resource, which means it is: (a) accessible to anybody who is an owner or herder of livestock, without account of his/ her origin; (b) difficult to exclude somebody from; and (c) not available for other users after the subtraction by somebody (Ostrom 1990). (ii) *Samata* trees in livestock pens, in private agricultural fields and near houses are accepted and respected as a form of private property (individual, family) according to the *lilin-draza*. (iii) There is collective property that is excluded from any form of use, like ritual trees and sources of shade in community places like the market. Over the past three decades people have expanded their private property claims on additional *samata*. The acceptable distance of private use around the livestock pen and the size of enclosures in the pastoral area have been discussed on different levels (*fokontany*, commune, clan), but no overlapping *fokontany* solutions have been attained yet. Triggered by increasing conflicts over this fodder plant in a few *fokontany*, some *chef de fokontany* addressed the mayor of the commune Beheloke who convened a meeting on the commune level in 2010. Although the mayor and the chefs de *fokontany* promoted an establishment of a rule, they still have not agreed on a communal *dina*. Finally the mayor transferred the responsibility back to the *chefs de fokontany* "because they are closer to the people" (mayor, Beheloke haut, 2011, quote 15:2). The following examples demonstrate that nearly similar constellation of actors can nevertheless cause very different ways of rule negotiations.

Figure 3. Cattle herder cutting *samata* tree (*Euphorbia stenoclada*).

In the *fokontany* Beheloke *haut* the *chef de fokontany* consulted the clan chief of the Temahaleotse, who was also the lineage chief of the Tembalaolake, before the communal meeting took place. The clan chief required the liberalisation of *samata* up to 30 private *samata* trees around a livestock pen. The rest is declared public for all Tanalana people and their guests. "Concerning the [*samata*] appropriation, the elder [clan chief] mentioned the ancestors are the owner of the *samata* plants and the land where the *samata* grows is also the ancestors' property. Therefore, nobody has the right to appropriate the *samata*. The *samata* has to be expropriated." (Local resident, Beheloke haut 2011, quote 13:5).

But the majority of the elders of the main lineages promote the measurement of one hectare of private *samata* (30 *tratra* = about 50–60 square meters) around the livestock pen. Nevertheless, many elders are convinced that an effective regulation needs the moral support of the chief, who can reinforce sanctions through his direct relationship to the traditional creator (*Zanahare*). That is why they try to convince or instrumentalise the traditional chief for their purposes but the clan chief refused to change his initial statement. Additionally, intra- and inter-lineage differences, caused by different amounts in cattle and hence different needs for *samata*, hinder common agreement. This situation supports my statement that most of the traditional chiefs had more a function as a consultative and morally supportive organ rather than a position as real decision maker.

Another example of rule negotiation took place in the *fokontany* Marofijery. Some 30 years ago the ex-lineage chief of the Tantsihay (clan Tevondrone) and the surrounding elders supported a mutual idea and established a rule for some aspects of *samata* use, limiting the private use to one hectare around the livestock pen, only one of which is permitted per cattle owner. Although the content of this rule is perceived as *lilin-draza*, the negotiation process is remembered and can be described by the majority of the cattle herders. The process is also continuously revisited as persons with large livestock herds often transgress this agreement. This situation shows that *lilin-draza* are not timeless and unchangeable. Similar to statements from Beheloke *haut*, the majority of interviewees from Marofijery (elders and young men) underline the importance of including the traditional chief and the ineffecti-

veness of state institutions. "It is an initiative of the community and permitted by the *mpitan-kazomanga* (lineage chief of the *Tantsihay*, part of the clan Tevondrone), so that means it is a *lilin-draza* (rules of the ancestors) (…) [W]hen it is a *lilin-draza*, it is the responsibility of the traditional chief and not of the *chef de fokontany* (…) If it was a *dina*, I'm sure that it would fall through. We take care of our *lilin-draza*, so we accept the regulation of the private *samata* because we are determined by the fundamental rules, which are the *lilin-draza*." (local resident, Marofijery 2013, quote 104:1). "It's right that there are state institutions like the mayor and the *chef de fokontany* but we have always to ask for permission of our traditional chief because we people of the littoral respect our *lilin-draza*. (…). The *chef de fokontany* also has to obey the *lilin-draza*." (local resident, Marofijery 2013, quote: 114:1).

Although a greater consensus about the regulation of the fodder plant exists in Marofijery than in Beheloke *haut*, no new rule (*dina*) could be established or no already existent rule (*lilin-draza*) could be re-established either. Even if a clear consensus concerning the private status of *samata* (inside livestock pens, agricultural fields and near houses) and the non-usable collective *samata* (ritual trees, providers of shade) exist, the sanctions for transgressions are contextually negotiated. While in one case the culprit had to pay two sheep for logging a tree on the market place, another person who cut several trees in another's agricultural field was not punished at all. The first person had already taken another tree from this place without permission and the act damages the whole community as they lose a source of shade. The second person had destroyed more trees but it was on their kin's field. These examples illustrate that even based on the same rule, different settings and conditions cause different sanctions.

Both *fokontany* cases explored above, Beheloke haut and Marofijery, show that the establishment of rules is a long-term ongoing process. Rules that are already established have to be renegotiated after a certain time and in cases of transgression, are variously interpreted. Moreover, which levels are used for a rule negotiation process, and the order of these, is not fixed and depends on the personal skills of certain people. Finally, actors and their responsibilities on administrative levels (*fokontany* and commune) and social levels (clan and lineage) overlap and hinder a clear reference framework for the establishment of rules. In the following section I will discuss these problems by analysing different forms of local rules and levels in the context of CBM.

DISCUSSION

IMPACT FOR COMMUNITY-BASED MANAGEMENT IN THE BUFFER ZONE OF TSIMANAMPESOTSE NATIONAL PARK. One of the main questions in the CBM context is how to anchor the COBA associations; there is the choice between a geographic level (*fokontany*) or a social level (clan, lineage), and there is also a choice of what form of agreements and rules (*dina*, *lilin-draza*) to use (Blanc-Pamard and Rakoto Ramiarantsoa 2007, Pollini et al. 2014). Most of the COBAs in the research area, like most across Madagascar, are composed of voluntary members from one or more *fokontany* (see Figure 4, Model I) While the initial idea of the GELOSE-law aims for a transfer of management rights to the whole *fokontany*-based community (the administrative sense of *fokonolo*) (see Figure 4, Model II), the passed law text only supports the foundation of an exclusive unit which does not include all resource users (Pollini and Lassoie 2011). Attention is drawn here again to the Tanalanas' perception of *fokonolo*, which has two dimensions: they have a trans-*fokontany* identity (lineages and clans), the territorial reference of which is the ancestral tomb, and a *fokontany-fokonolo* identity, which comprises the inhabitants of a clearly defined administrative territory, the *fokontany*. There are hence three possibilities for composing the membership of a COBA association: (i) voluntary members of one or more *fokontany* (Figure 4, Model I), (ii) all resource users in a *fokontany* concerning the administrative unit (Figure 4, Model II) or (iii) all resource users in all *fokontany* that concern the clan level (Figure 4, Model III).

Because of the Tanalana's trans-*fokontany* identity, it is difficult with *fokontany-fokonolo* decisions to restrict natural resource use outside of the private areas (e.g., fields and livestock pens). All resources in this area, including *samata*, are perceived as 'common property' (sensu Ostrom 1990) and are accessible to everybody. This perception of property suggests that *fokontany* boundaries are of little importance for the management of natural resources. Some conservation agencies try to manage the trans-*fokontany* border use of natural resources by integrating several *fokontany* in one COBA association, but these are also only composed of voluntary members and exclude other users of natural resources (see Figure 4, Model Ib) (see also Andriamalala and Gardner 2010).

Despite trans-*fokontany* identity and resource use, Tanalana make agreements and discuss rules with clear *fokontany* boundary reference. The small social pact (*titike*) and the rules for *samata* use were applied and discussed mainly on the *fokontany* level. Solutions were additionally searched on the trans-*fokontany* boundary or clan level, but with less influence on daily behaviour. Ostrom (1990) argues that for successful collective action in natural resource management it is important to define clear boundaries of the people who are using the resources. She specifies this aspect in further publications: "membership [to a user group] may also be marked by symbolic boundaries and involve (…) rituals and beliefs that help solidify individual beliefs about the trustworthiness of others" (Ostrom 2014). In line with this, I argue that it is useful to take a look at these locally initiated agreements, analyse their level of effectiveness and prove their usability for reorganising the community-based natural resource management associations.

In our study, the negotiations observed on the *fokontany* level concerning the use of *samata* aim only to control the privatiza-

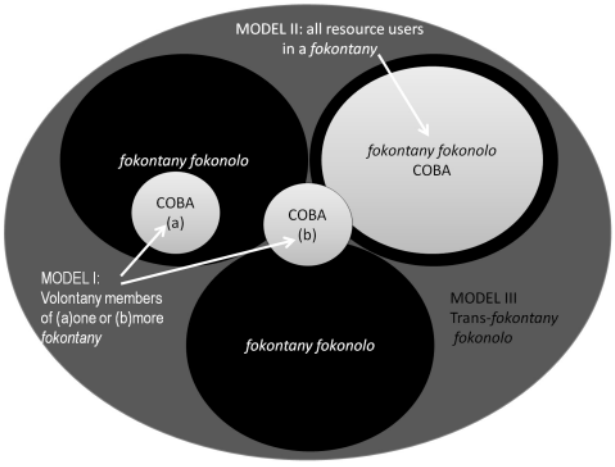

Figure 4. Proposed models for composition of the community-based management associations COBAs (*communautés de base*). (modified from Pollini et al. 2014)

tion process inside a *fokontany*; there is no restriction on general use of common *samata* by others as this contradicts the trans-*fokontany* identity (cf. Goetter 2016). Interviewees mentioned that the reason for integrating the clan chief in the discussion process was not the need to restrict common property access for persons not part of the *fokontany-fokonolo*, but rather to morally support the decisions made on the lineage level concerning the respective *fokontany-fokonolo*. Our study supports the conclusion of other researchers that the *fokontany-fokonolo* level, based on the main lineages, is the reference framework for decision making (cf. Blanc-Pamard and Fauroux 2004, Muttenzer 2010). The same is true for the small *titike*, which is performed with the respective *fokontany-fokonolo* members and transhumance guests (Goetter 2016). In spite of the Tanalanas' trans-*fokontany* identity and resource usage, this study shows that the clan level and its authorities are not as action orientated as the lineage level (*fokontany-fokonolo*). Consequently, the clan level is not the most effective form to anchor CBM associations. This does not imply a lack of clan identity but only shows the limit of clan authority to influence daily behaviour. The following quote underlines this finding: "This initiative is born in the community of Marofijery. As inhabitants of Marofijery it is our task to find the adequate rules. We do not have to wait for the decision of the clan chief because the clan chief does not have the right to put pressure on our organisation. We have to focus on the essential things in our *fokontany*. It is the task of our lineage chief who tries to find a consensus for the well-being of our *fokontany* and a well-established rule." (local resident, Marofijery 2013, quote: 114:2).

The question then arises, could *lilin-draza* or *titike* on a *fokontany* level be a basis for the CBM association's rules? Although researchers have shown that sometimes existing forms of local agreements or institutions can provide more acceptance and respect for CBM structures (Kull 2002, Horning 2003b, Blanc-Pamard and Fauroux 2004), others question their use. For instance, Blanc-Pamard and Fauroux (2004) question the usability of a *titike* or *lilin-draza* for CBM among another ethnic group in the southwest of Madagascar, the Sakalava, because of the conservative nature of these rules which reinforce the existing power structures. Additionally, Kull 2002 and Pollini et al. 2014 warn against ignoring the ethnic heterogeneous composition of local societies and hence of COBA associations when forming COBA associations. This critique is valid if we are proposing already existing structures as possible forms for CBM because the *fokonolo* does not consist of the whole lineage/ clan or all the inhabitants of a *fokontany*; it is a constantly changing group of persons dominated by the elders of the main Tanalana lineages (for another example in Madagascar, see Goedefroit 2006). The ethnic heterogeneity is partially taken into account since Tanalana authorities discuss and make the pacts and rules, Mahafaly and Vezo groups participate in the ritual procedure and/ or in the financing of the sacrificial animal. They are morally connected through social and kinship relations with the Tanalana, who are then responsible that these related groups respect the agreements. For the duration of their stay, seasonal Mahafaly migrants are temporary members of the Tanalana society and thereby have to follow local rules and pacts. Horning argues that "social contracts" or social pacts are only practiced when there is a special need for social cohesion on selected issues in ethnic heterogenic societies (Horning 2003b). However, this study observes that *titike* both on the *fokontany* and clan levels are not only practiced to enforce social cohesion between different ethnic groups (Tanalana, Mahafaly and Vezo groups) but also within Tanalana society.

Further arguments question the application of a *titike* in the CBM context: cattle and other goods that are integrated in the *titike* are by consensus classified as private property and are thereby not allowed to be used by others, while forest resources are common property and can be used by everybody. The social pact does not contain concrete formulations of sanctions. If a *titike* is applied for CBM, the content of the given *titike* needs to be discussed at the same level of detail as it was for the fodder plant rule negotiation process. While the *titike* is more of a spontaneous reaction to a menacing security situation, the CBM needs a long-term, more or less stable arrangement. A *titike* thus cannot serve as a replacement for a *dina* but it could work as reinforcement.

Regulations for forest resources managed through CBM contracts have mainly failed because of the different economic interests and the trans-*fokontany* 'use right philosophy' (sensu Esoavelomandroso 1989), as also seen in the case for the fodder plant negotiations. The *samata* case illustrates the time needed for negotiation processes over use restriction, as well as specifically demonstrating that local actors often reject the application of trans-*fokontany* rules for trans-*fokontany* resources. These examples show some of the limits for CBM management arrangements.

CONCLUSION

Although the CBM approach aims for local population participation, the content, manner and speed for the establishment of rules are highly influenced by conservation agencies. Examples worldwide have shown that locally evolved rules are more binding for local people than externally imposed or initiated arrangements (Baland and Platteau 1996, Ostrom 2000, Horning 2004). Nevertheless, it is important to state that local rules are neither entirely respected, nor are they per se sustainable or effective for biodiversity conservation (Walsh 2002, Horning 2003b, 2004).

If conservationists are interested in supporting collective action for sustainable resource management on local levels, they have to be aware of long periods of rule negotiation (Berkes 2004, Goetter and Neudert 2016). Even when the moment of establishing a rule arrives, it is important to remember that existing rules are constantly being renegotiated. Furthermore, each existing rule is interpreted depending on the context and does not raise the claim of general validity and stability. Agreements that are made in a specific context (e.g., cattle theft) or for a specific resource (e.g., *samata*) cannot be transferred automatically to other conflicts or other natural resources.

Rules that are established in the context of CBM (*dina* GELOSE) are subject to the same mechanisms as locally initiated rules (*lilin-draza, titike*): transgression and adaption to individual needs are an integral part of the system (Rives et al. 2013). It is difficult to find the right form of agreements for CBM and also to identify the right level to anchor the CBM association. Each level is problematic in different ways : (i) A COBA association consisting of voluntary members of one or more *fokontany* (Model Ia and b), excludes other resource users (Pollini and Lassoie 2011), (ii) a COBA association consisting of all people in a *fokontany* (*fokontany-fokonolona*) (Model II) contradicts the trans-*fokontany* resource use philosophy (Goetter and Neudert 2016), and (iii) a COBA association on the commune or clan level (Modell III) is not action orientating for the local people in their daily behaviour (Kull 2002,

Blanc-Pamard and Fauroux 2004). The optimal solution would be to establish a *dina* on the commune and *fokontany* level based on a rule of ancestor or taboo that includes at least all Tanalana clans and is reinforced annually by a *titike* that obliges other ethnic groups to follow the agreement. However, this is only possible for some specific resources and not for the whole set of rules needed for CBM.

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SUPPLEMENTARY MATERIAL.

Available online only.

Table S1. Different types of rules in the context of natural resource management.

ARTICLE

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Local community perceptions of conservation policy: rights, recognition and reactions

Marketta Vuola[I] and Aili Pyhälä[II]

Correspondence:
Marketta Vuola
University of Helsinki
Helsinki, Finland
Email: marketta.vuola@alumni.helsinki.fi

ABSTRACT

Biodiversity conservation in post-colonial contexts typically takes the form of state-imposed protected areas. Such conservation strategies, especially when failing to involve local communities, have resulted in conflicts between protected area managers and local communities, thereby diminishing conservation effectiveness. This research examines local community institutions, perceptions, and involvement with regard to the management of Ranomafana National Park, South-Eastern Madagascar. Data was collected at the end of 2014 in five case study villages around the park. Our findings indicate that imposed protected area regulations have provoked a wide range of mostly negative reactions amongst local villagers, largely due to lack of communication and negotiation on the part of protected area managers. What few attempts have been made to involve local communities in conservation and development activities have been met with local skepticism and have only served to reinforce existing power asymmetries within local communities. We argue that increasing local autonomy would help to boost local villagers' self-esteem, and enable local communities to have a more equal playing field for future negotiations with conservation authorities. Furthermore, this would also likely trigger more local interest, initiative, and ownership with regards to conservation. Although the Ranomafana National Park area is currently regarded by many local villagers as illegitimate, there is widespread willingness across all five communities to collaborate with conservation authorities, presenting enormous potential for more successful conservation; potential that – at least to date – remains untapped.

RÉSUMÉ

Conserver la biodiversité dans un contexte postcolonial se matérialise généralement sous forme de zones protégées établies par l'État. Cependant, ces stratégies de conservation mènent souvent à des conflits entre gestionnaires et communautés locales, affectant en retour leur soutien à la mise en place de zones protégées. Les conservationnistes reconnaissent donc de plus en plus l'importance de considérer l'engagement des communautés locales dans la prise de décisions et la mise en œuvre d'actions de conservation, afin notamment que ces actions soient efficaces.

Cette étude se focalise sur les institutions des communautés locales, leurs perceptions et leur engagement concernant la gestion du Parc National Ranomafana, au Sud-Est de Madagascar. Les données furent collectées à la fin de l'année 2014 dans cinq villages situés autour du parc. Nos résultats indiquent que les réglementations imposées par le parc ont provoqué un large éventail de réactions, principalement négatives, de la part des villageois, dû à un manque de communication et de négociations de la part des gestionnaires du parc.

Les quelques tentatives d'inclusion des communautés locales dans les patrouilles de surveillance du parc n'ont servi qu'à renforcer les asymétries de pouvoir pré-existantes. De même, seulement une petite partie des résidents locaux peuvent bénéficier de la gestion du parc. Les familles les plus vulnérables économiquement continuent à dépendre étroitement de ressources forestières dont l'exploitation est interdite, risquant des sanctions de la part des gestionnaires du parc qui perturbent encore plus la cohésion sociale à l'échelle locale. Les autorités sont en retour réticentes à accorder leur confiance aux villageois. Même si l'on ne peut pas s'attendre à ce que ce cycle de méfiance disparaisse soudainement, les tensions actuelles entre communautés locales et gestionnaires du parc doivent s'estomper si le but est d'obtenir une gestion durable du parc à long-terme.

Nous nous prononçons en faveur d'une plus grande autonomie locale qui permettrait non seulement de développer l'estime de soi des membres de la communauté, mais susciterait également plus d'intérêt et d'appropriation envers les actions de conservation, permettant ainsi aux communautés locales d'être sur un pied d'égalité lors de futures négociations avec les autorités du parc. En conclusion, alors que la zone protégée est majoritairement perçue comme illégitime, il existe une volonté réelle de la part des cinq communautés de collaborer avec les autorités chargées de la conservation, présentant un potentiel énorme - qui

I University of Helsinki, Helsinki, Finland
II Metapopulation Research Centre, Department of Biosciences, PO Box 65 (Viikinkaari 1), 00014 University of Helsinki, Finland

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reste pour l'instant inexploité - en terme d'amélioration des actions de conservation.

INTRODUCTION

Madagascar is one of the world's biodiversity hotspots and a priority target for biodiversity conservation with its high rate of endemism, diversity, and level of threats (Myers et al. 2000). One of the major challenges for conservation in Madagascar is the current socio-economic condition: the country is among the ten poorest countries in the world (as measured by GDP per capita) with a large, and rapidly growing, rural population (annual rural population growth of 1.8 %) that, due to direct livelihood dependence on natural resources, places tremendous pressure on the island's remaining intact ecosystems and habitats (World Bank 2016, data from the year 2014, Aymoz et al. 2013). One of the most commonly proposed solutions has been to establish protected areas (PAs) that exclude local people from further threatening the endangered natural habitats, as in many other contexts worldwide (e.g., Brockington 2002).

In the Global South, PAs are often established in areas that are already inhabited by small-scale rural communities whose livelihood depends largely on the direct subsistence use of natural resources (Adams and Hutton 2007, Mombeshora and Le Bel 2009). This, in practice, usually leads to local populations suddenly finding themselves confronted with a powerful and externally imposed conservation agenda that not only deprives them of some of their natural resource management regimes, but also leaves them with little compensation or benefits (Naughton-Treves et al. 2005, West et al. 2006, Scales 2014). Moreover, local communities tend to pay the highest price for global conservation efforts (Agrawal and Redford 2009). Therefore, protected areas have in many cases resulted in local resistance and rejection (Cox and Elmqvist 1997, Brockington 2004). The strict protected area model has been criticised over the years for being not only unethical towards local community rights (Brockington et al. 2006, Pyhälä et al. 2016), but also costly (Watson et al. 2014). Moreover, the effectiveness of this model has been questioned. While some comparative studies show rather good results for PAs (at least in forest habitat restoration: Geldmann et al. 2013), there are also studies reporting biodiversity decline in a significant percentage of PAs around the world (Laurance et al. 2012). Laurance and colleagues further show that conservation effectiveness is often influenced by what takes place just outside PA borders.

Despite the apparent conflicts, rural livelihoods depend directly on surrounding ecosystems, and local communities are therefore argued to have substantial common interests with conservation planners (Berkes 2004). In other words, at least in theory, it is in the interest of local populations to safeguard those resources upon which their livelihood depends. For instance, Martinez-Alier (2013) points us to a concept that he refers to as 'environmentalism of the poor', which states that in many conflicts concerning large-scale resource extraction or waste disposal, poor people often support the preservation of nature rather than industrial development (Martinez-Alier 2013). Conservationists have sought to tap into these common interests and, already since the 1980s, there has been a gradual move towards more inclusive conservation strategies (Kothari et al. 2013). Indeed, several cases in the academic literature demonstrate that genuine partnerships with local communities offer long-term biodiversity protection while also supporting the wellbeing of local communities (Schwartzman and Zimmerman 2005, Vermeulen and Sheil 2007). Thus, at least in theory, there is a huge lost potential in not building stronger alliances between conservationists and local communities (Redford and Stearman 1993, Brosius and Russell 2003, Berkes 2004). Especially in most tropical low-income countries where local and state institutions tend to be weak, Barret et al. (2001) recommend cooperation and distribution of authority among several local, state, and international institutions.

The conceptual division between humans and nature, deep-seated in Western modes of thinking, was reflected in the initial creation of the PA model in the nineteenth century USA and continues to influence much of the global conservation paradigm still today (Adams and Hutton 2007, Mombeshora and Le Bel 2009). This dichotomy between humans and nature is, however, rarely the philosophy held by local communities with regards to human-nature relations (Berkes 2004). Comparative studies show significant overlap of high biodiversity and cultural and linguistic diversities developed during the millennia of human-nature interaction (Balée 1994, Maffi 2005). Indeed, local institutions around the world are usually built around the use, allocation, and management of certain resources, and can therefore even be in contradiction with certain goals of modern conservation strategies (Berkes 2004). This may make it challenging for conservation planners to regard local people as allies, and vice versa. Moreover, finding a common language, let alone epistemology or worldview, and defining common objectives that would benefit both stakeholders, is tasking and time-demanding, to say the least.

This paper presents a case study of the Ranomafana National Park (hereon RNP) in South-Eastern Madagascar, from the perspective of the local community. We question what can be learned about local people's own agency and initiative in conservation. In other words, how aligned are local perceptions, aspirations, and realities with externally imposed conservation agendas, and how could the latter be improved so as to work with, not against, local community interests? The study is based on the tenet that, as resource users, local communities have an essential role in shaping conservation outcomes.

We examine the above questions from a lens of political ecology, defining nature conservation as primarily a social and political process, and a matter of human organisation (Brechin et al. 2002, Berkes 2004, Robbins 2012). We base our study on the premise that the strength of human organisation, i.e., the commitment and cooperation of social actors, ultimately defines the success in reaching biodiversity conservation targets (Brechin et al. 2002). According to some scholars, in order for conservation to be effective, it should already in the planning process address the local communities' human dignity (or environmental justice, see Schlosberg 2013) and representation in governance as well as how the legitimacy of conservation governance is ensured locally (Brechin et al. 2002, Adams and Hutton 2007). Moreover, understanding natural resource management requires analysing the relationship among institutions at different scales of governance and across formal and informal spheres (Ostrom 1990, Agrawal and Gibson 1999, Leach et al. 1999). While our study is focused at the local community level, we also present an overview and discussion of how conservation actors work and interplay across multiple levels and spheres in Madagascar, including the authority they hold, the rules and norms that guide their action, and the social implications that conservation policies have on the ground.

CASE STUDY: RANOMAFANA NATIONAL PARK

Ranomafana National Park (RNP) is located in the regions of Haute Matsiatra and Vatovavy-Fitovinany in the tropical rainforest mountainous range of eastern Madagascar. The local communities have, according to some assessments, settled the area since the late 18th and early 19th centuries (Ferraro and Rakotondrajaona 1992, as cited in Peters 1999). The majority of the residents belong to one of two self-identified ethnic groups, the Tanala and the Betsileo, of which the Tanala inhabit low lands to the east and the Betsileo the highlands to the west of the National Park (Korhonen 2006). These local communities continue to depend primarily on subsistence agriculture and gathering of forest products, including honey, crayfish, and materials for handicrafts (Kari and Korhonen-Kurki 2013). The rapid rate of population growth continues to place ever more pressure on land and resources, with cultivations expanding to new – including forested – areas.

The RNP project was initiated in 1991 as an integrated conservation-development program funded by USAID, and organized by two U.S. universities (Peters 1998, Hanson 2012). As a part of this process, the Centre ValBio (CVB) was established in 2003 next to the PA. It continues to be a significant actor today with its core missions of facilitating research, reducing poverty and encouraging environmental conservation by developing ecologically sustainable economic development programs in the area. In 1998, the RNP's management shifted to the Malagasy national government, specifically to the ANGAP (*Association Nationale pour la Gestion des Aires Protégées*), responsible for park management, conservation education, rural development and promotion of ecotourism, and to MICET (*Madagascar Institut pour la Conservation des Écosystèmes Tropicaux*) who were responsible for facilitating biodiversity research and health projects (Korhonen 2006). Later, ANGAP changed its name to Madagascar National Parks (MNP), who holds full management responsibility over the park today.

Even though MNP claims to include co-management with local communities within its conservation approach (MNP 2014), it has been criticised of centralised planning that has, throughout its history, lacked the effort to address local social, cultural and economic conditions as well as historical ties to land (Peters 1999, Hanson 2012). Peters (1999) describes the disconnect between the creation of RNP and the 160 local villages: many of the remote villages around the park remained unvisited by park managers, even long after park establishment, with some villages even unaware of the creation of the park, let alone its purpose or meaning (Peters 1999). According to Peters, many locals thought that it was "*an attempt by the foreigners to take away their land*" (Peters 1999: 69). The initial integrated conservation and development approach lacked any official recognition of resident peoples' rights to self-determination, as well as any public debate (ibid.), and these shortcomings inhibited the success of development activities aimed at supporting local communities' wellbeing (Hanson 2012). The imposed conservation policy continues to cause highly uneven distribution of costs and benefits; the restrictions on natural resource use have the greatest impact on local households (Ferraro 2002) and the development initiatives imposed by conservation authorities have resulted in few improvements in local communities' situation (Korhonen 2006).

METHODOLOGY

The data for this research was collected mainly from field work conducted in November–December 2014 in the Ranomafana region. The five study villages were chosen based on logistical, temporal, and safety limitations – no statistical sampling based on e.g., the distance to RNP or other criteria was possible. Two to four days were spent in each study village as well as one afternoon in the village of Ambatolahy. Prior to the actual data collection in the sample villages, we pilot-tested our interview in the village of Ambodiaviavy (a Tanala village also bordering the park). Free prior informed consent (FPIC) was obtained in all of the villages and with each informant prior to data collection. With the help of CVB, research permits were asked from the study villages before arriving to them. We organised a village meeting upon our arrival at each village, to allow us to explain the purpose of our visit, how we would use the data, their rights to anonymity, and that their participation was completely voluntary. The same was explained in the beginning of each individual interview. Some individuals did in fact choose to opt out of the study, which emphasizes the importance of researchers carrying out FPIC and stressing voluntary participation. Figure 1 presents the study area. The five main study villages are Manokoakora, Amboditanimena, Vohiparara, Ranovao, and Torotosy and the additional study village is Ambatolahy.

The data collection in the study villages included village meetings (n=5), village-level key informants (n=5) and semi-structured interviews with randomly selected residents (n=44). Our goal was to obtain a geographically balanced sample of each village, as much as possible. Therefore, in each village, we visited households in different parts of the community and interviewed as many households as we could, providing of course that each participant was willing to be interviewed. In most households we interviewed one, sometimes two persons. Sometimes we also interviewed individuals outside of their household, if we happened to meet them elsewhere in the village setting. No other criteria were applied to our sampling, other than that we paid close attention to getting as equal a representation of male and female informants as well as different age groups. The interviews and other com-

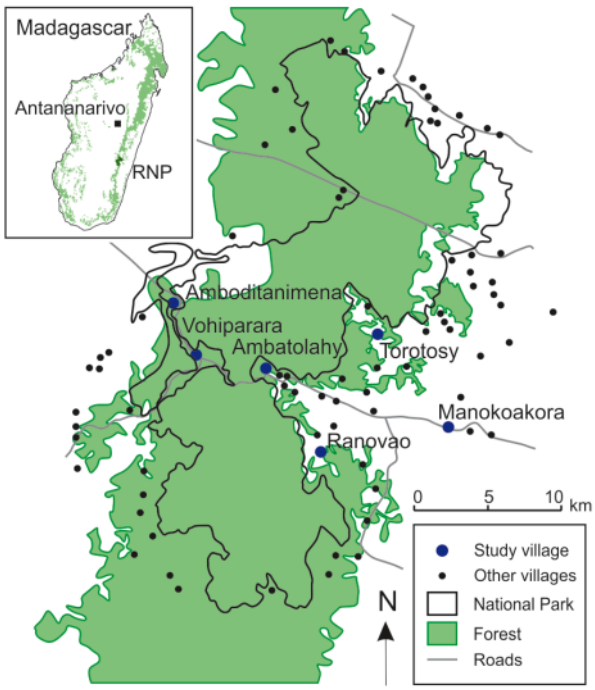

Figure 1. Study area with boundaries of the Ranomafana National Park and locations of the study villages.

munications were conducted in Malagasy and translated to us by two Malagasy Masters students who were simultaneously carrying out their own fieldwork in collaboration with us (see Acknowledgments).

The interviews were open-ended and semi-structured, with the key thematic points being: social-ecological changes in the area; impacts of RNP on the individual's life; perceptions of RNP and conservation; involvement in, and perspectives on, development and conservation projects and related community associations; rules (formal and informal) and actors related to conservation and natural resource management; possible internal and external conflicts related to conservation and natural resource management, and; their own household's livelihood and agricultural methods.

In addition to interviews, we carried out three focus group discussions (n=3) in the village of Ranovao. Participant observation was carried out throughout the stay in each village in order to validate our findings and provide a general understanding of the way of life and the environmental context. Participant observation included planting rice with the villagers, visiting forest fragments and cultivations surrounding the settlements, and simply spending time with villagers.

In addition to the in-village data collection, a handful of identified experts (n=5) were interviewed in order to gain a wider understanding of the interplay of actors involved in conservation activities and enforcement across levels, as well as to shed light on the broader cultural and political context. We interviewed experts from CVB's Monitoring and Partnership Department and Conservation Education and Outreach Department. They provided us with detailed information about the area, its population and culture, as well as the local conservation and development programs they were implementing. We also interviewed one of the authorities of MNP about the PA management practices and challenges faced, specifically vis-a-vis local communities. We also interviewed two representatives of the Association of Guides of RNP (the actors most directly gaining monetary benefits from conservation). They told us about their perspectives on conservation and the actors involved, and how RNP is benefiting not only them but also their community and other local communities. The final expert interview was with the local police, who told us about the patrolling in the PA and the nature and frequency of illegal activities taking place in the PA.

The village-level interviews, focus group discussions and village meetings were transcribed and analysed using Qualitative Content Analysis (QCA) (e.g., Bazeley 2013). We used codes to label key topics, the attitudes and meanings associated with these topics, and more analytical remarks or conclusions derived from the data. We ended up with 181 specific codes, which in turn were grouped under 22 broader theme codes (e.g., positive/negative/indifferent attitude towards MNP, effects of conservation on livelihoods, views on how the environment should be protected).

Using discourse analysis to unravel the interview material, and systematically coding all topics, the analysis revealed to us a wide range of overlapping and sometimes contradictory views, actors, norms, rules, events, and attitudes related to conservation, natural resources management and land struggles at large, which in turn gave us glimpses into the complex realities, relations and interests at stake – all influencing how local communities feel about RNP management. QCA also served well for bringing up the variety of meanings held by informants (Supplementary Material).

RESULTS

RNP was implemented with a core area allocated for strict biodiversity preservation, and where human impact is minimised. Harvesting is strictly prohibited but local people are allowed to trespass through the park boundaries. The core area is surrounded by a 2.5 km wide buffer zone, a mosaic of forest fragments and cultivations. The rules concerning the use of forests along the buffer zone vary. Table 1 summarises these in the case of each study village. Almost no forest areas in the buffer zone are managed by local communities, the exception being one area managed by the village of Vohiparara at the western side of the PA. It has after some struggles managed to obtain from MNP a community-managed forest of 25 hectares. The villagers use the forest e.g., for gathering of non-timber forest products, collecting wood for fire and construction, and for rituals.

In contrast, the history of Amboditanimena, only five kilometres from Vohiparara, is somewhat different, namely one of forced relocation. The people of Amboditanimena reported that soon before the establishment of the RNP, the community had relocated to wetland valleys within the PA, where they lived and cultivated rice paddies. When the RNP was established in 1991, they were promised that they could continue cultivating in the 2.5 km wide buffer zone but, to the surprise of the villagers, in 1999, MNP changed the limitations of the park and this part of the buffer zone was merged into the strict PA zone. The gendarmes came to evict residents from their homes and relocated them to the area where the village of Amboditanimena is now located. Currently, the village has no real buffer zone separating it from the PA and thus it has no right to harvest from the surrounding forests.

At the eastern side of the PA, all study villages apart from one (Manokoakora, which is further away from the PA) have forest fragments near PA border that are controlled by the Chef Forestier who operates under the Ministry of Environment and Forests. Local people are allowed to log on the hillsides, but only up to a certain altitude, as hilltops must always be left untouched (according to the law and enforced by the *Chef Forestier*). The topography of the eastern region is very steep and fertile lowland is limited causing pressure to expand cultivations higher uphill. As almost no forest remains in the valleys, people have to buy logging permissions from the *Chef Forestier* if they need wood – a process described by local villagers as difficult and expensive. This results in many hill tops becoming bare and illegal logging and burning continuing throughout the region.

NATURAL RESOURCES MANAGEMENT AT THE COMMUNITY LEVEL. All study villages have a set of *fady* or taboos that serve to guide the harvesting and use of some species. For example, in Amboditanimena, crayfish cannot be caught for

Table 1. Study villages. (Number of inhabitants, CVB 2013)

Name	Nbr of inhabitants	Ethnic group	Nearest forested area
Vohiparara	325	Betsileo	Community-managed forest
Amboditanimena	240	Betsileo	Located directly at the RNP border with no buffer forest
Manokoakora	550	Tanala	No remaining forest near the village
Ranovao	341	Tanala	Buffer zone / forest fragments
Torotosy	286	Tanala	Buffer zone / forest fragments
Ambatolahy	265	Tanala	Buffer zone / forest fragments

commercialisation, only for self-subsistence. However, in almost all study villages, the interviewees told us that they do not have any community-based rules or norms for the use of land and its species. More detailed studies on traditional environmental knowledge have observed these *fady* to be losing their relevance in local people's lives and local natural resources management (see Jones et al. 2008). Indeed, the laws prohibiting burning and gathering are repeated in the interviews much more often when the question is about land and resource use rules. Even though *fady* and other community-based norms exist, most of our informants did not regard them as rules for natural resources management in the same way, for instance, as national laws are seen. Essentially, there seem to be two systems of norms in place, i.e., local norms and national laws, and while potentially working towards the same goal, the two do not currently benefit or strengthen one another.

Similarly, the RNP authority that we interviewed does not mention any community-based or traditional natural resources management practices that could support conservation (Expert interview 3). The expert from CVB confirms the same perception that the traditional culture and values that used to shape local natural resource governance regimes have been lost (Expert interview 2), having been replaced by external rules and western education. Ultimately, increasing poverty has also made the compliance to *fady* difficult especially if and when such compliance compromises everyday needs such as food. CVB and RNP have started offering environmental education and livelihood diversification projects in the local communities. The MNP authority argued that local communities have enough land to feed each household; the problem lies in unsustainable management practices and lack of local initiative (Expert interview 3). Yet, as mentioned above, most of the communities around RNP lack management authority over their surrounding forests.

From our CVB informant, we heard that particularly the Tanala are living in "*isolation and ignorance*" of environmental issues (Expert interview 2). Tanala livelihoods have traditionally been based on forest product gathering rather than agriculture, and CVB practitioners have found it extremely difficult to teach them new agricultural methods. The situation is further challenged by there being far less cultivable low land in the area inhabited by the Tanala than in the Betsileo area. The latter are described as more hard-working, active and open to new influences, and the agriculture development projects implemented to date have been more successful with them than with the Tanala.

Vohiparara is the only study village that is slightly exceptional with regards to community-based management, as it has the community-managed forest. The villagers seem to be very proud of their forest, which they tell is growing in size. As one informant told us: 'I think that maybe the whole life of this village depends of our forest.' (Community member, Vohiparara).

Villagers harvest wood from their forest for construction and fire. The only products gathered for commercialisation are honey and crayfish. The village chief has the formal authority to control the use of the community forest, but according to a key informant, management is mostly based on informal social control: if someone takes more than needed, others in the community will reproach them. Also, all major activities in the forest, such as cutting trees, require rituals that are performed collectively. The crayfish catching offers an example of community-based natural resources management: since the villagers have observed that the crayfish population in their forest has become very young, the community has agreed to pause harvest until the population gains age.

In each of the study villages, we found local people showing strong attachment to the land, both as their ancestral land to which they have strong cultural bonds, as well as their only asset from which to derive their livelihood. Whenever outsiders come in to log or mine gold in the buffer forest surrounding villages, the local villagers stated that they attempt to stop them. In such situations, the local communities have managed to get help from local authorities, namely the *Chef Forestier*, MNP, or the mayor, and have in most cases succeeded to keep the outsiders from harvesting.

In all but one study village (Vohiparara), several interviewees questioned the necessity of the PA, stating that it is not their traditional way of life that causes deforestation and that they do not need the PA to protect their forest. As one informant told us: 'We always protected the forest, but now the national park has taken from us the right to protect it and to take benefits from it. Way back people shared the forest and everyone was responsible for their own actions. We used to collect honey, crayfish, and keep zebus there. We also enjoyed walking in the forest. We still could go there but people do not go often anymore because they are afraid. RNP agents have told us that cutting a tree is like killing a person and exploiting the forest will be heavily punished.' (Community member, Torotosy). Hence, as seen in this case, even when local community rights to participate in decision-making are not recognised, local people continue to have a strong sense of ownership of, and belonging to, the land. They also reflect an opposition to the "exploiter" role that they feel they are given by conservation authorities.

SOCIAL IMPACTS OF CONSERVATION. The way local villagers feel about national laws regulating forest use was found to be a contested and conflictive issue in the communities we studied. In Torotosy, interviewees report that some villagers turn each other in to the authorities, namely to the *Chef Forestier*, for the illegal activities they have carried out, resulting in sanctions to the wrong-doers. Below, we discuss the possible reasons for this. Meanwhile, in Manokoakora, many villagers who take part in the popular community association for conservation, reforestation, and agricultural development advocate for abandoning *tavy* leading to frequent conversations and debates with those community members who want to continue the traditional practice. The laws on burning (i.e., those setting the limits and safer practices for burning) have offered guidelines by which *tavy* can be done within limits that community members can agree on, to some extent, but the argument is still ongoing. It is mostly members of local park patrolling committees who get paid by MNP (at least in Torotosy) and members of the community association, i.e., landowners (as in the case of Manokoakora), who advocate this shift away from *tavy*. In other words, these wealthier individuals can perhaps afford to lessen or altogether abandon *tavy*, as they can afford to meet their food needs in other ways while turning to promote conservation action instead. Meanwhile, poorer families may be left with no other option than to slash-and-burn.

Park patrolling committees (*Comité Local du Parc*, CLP) are an interesting example of how an attempt towards more participatory conservation may turn out to have unexpected social impacts. MNP defines patrolling as a form of co-management with

communities (MNP 2014) and in the interview with the MNP authority, patrolling was indeed the only concrete form of collaboration that was mentioned (Expert interview 3). Patrolling is carried out by CLP's that are founded in 47 communities around the park. Each participant is paid a daily salary by MNP for the patrolling operations that MNP organises irregularly (confirmed also in Expert interviews 3 and 5). From the point of view of a local villager, the membership in CLP might be a way of getting involved in conservation but, importantly, it also means an income opportunity, albeit an unreliable and sporadic one.

In two of the study villages, Vohiparara and Torotosy, some of the young men take part in the CLP and patrol the forest with a mixed brigade of local gendarmerie, police, and army personnel looking out for – and arresting – individuals who carry out illegal activities within the park (Expert interview 5). The problem is what happens when the patrolling is over and the mixed brigade are gone. As one local community patroller shared: 'The problem is that the criminals are armed and as they recognise the faces of CLP members they might take revenge. There is a tension between the villagers of Vohiparara and the criminals. There have been no attacks so far but CLP members are afraid because the criminals keep following them. They do not dare to go to the market for instance.' (Community member, Vohiparara).

At the Betsileo side of the PA, the majority of arrests concern artisanal gold mining by unorganised individuals, driven to this activity by sheer hunger and poverty (Expert interview 5). At the Tanala side, *tavy* practised by the local community members is keeping the authorities and CLP busy. One striking example of such an arrest is an incident told by a woman who explains that since her husband died, the family has been in trouble due to their desperate need to open new land for cultivation, but being unable to do so as it is considered men's work: 'My son was taken to Ifanadina to be punished for burning. He was only 12 years old and he had done it because he wanted to help his family by creating a small piece of field. He was sentenced to pay a 20 000 Ar. fine. It was people from both this and the neighbouring village who turned him in.' (Community member, Torotosy).

NEGOTIATIONS BETWEEN THE PA AND LOCAL COMMUNITIES.

The RNP authority emphasised the importance of local communities in shaping conservation outcomes. They explained that the RNP does not have the staff and capacity to control the 41 000 hectares of RNP and thus need to collaborate with local communities. Based on their experience they felt that only some, but not all, communities and individuals are motivated to collaborate with the MNP (Expert interview 3).

The literature we reviewed shows that throughout its history, RNP has been managed in a strict top-down fashion. Even though there are some villagers who find the rules of RNP reasonable, the majority we interviewed have difficulties accepting them. In the Tanala villages bordering the PA, the villagers tell that they are so afraid of the Chef Forestier and PA guards that they do not even enter the forest anymore. Meanwhile it is evident that wood (for fuel and building purposes) is still being collected and new fields being opened, despite both activities being illegal. There has even been some small-scale gold mining and harvesting of valuable species to be sold in unofficial markets – both of which have become attractive options for those in desperate need for quick income (Expert interview 2). Such illegal activities are carried out at a great risk, and as described above, arrests are common.

The elders we discussed with shared that the PA borders or rules were never negotiated, and some of them said they feel betrayed by conservation authorities who extracted their local knowledge to later create the PA. The perceived disrespectful role played by MNP and the fact that there has been no local participation in decision-making, trigger very negative attitudes. Also, the majority of local villagers expressed frustration due to having no means to communicate with authorities or to influence the rules that so directly affect their lives. Even though the majority of the interviewees express a will to cooperate with MNP, the problem – as expressed by the villagers – is that MNP decides when and how to communicate: 'Sometimes we do some cooperation with MNP. I can only hope that MNP wants to cooperate with us because it is the authority. The villagers always want to hear what MNP has to say.' (Community member, Torotosy).

There are also individuals in each community who want to change the relationship between the communities and MNP – rather than outright rejecting MNP. This viewpoint was especially strongly expressed in Amboditanimena, the village where we had expected the residents to be most resentful towards MNP due to their history of forced physical displacements. Residents of Amboditanimena hope that MNP would be more flexible and negotiate land rights with them but they stress that they have not yet been able to have any discussion with MNP staff.

The lack of perceived participation and communication in the management of RNP has a range of consequences at the local level. The ways in which the rules are negotiated and enforced as well as any contact that local people have with MNP personnel affect local people's sense of being respected and heard, and thus of feeling equal in the playing field. The extent to which the rights and human dignity of local people are respected ultimately defines whether they are likely to develop a feeling of ownership of a new project (such as managing a PA), and thereby also view the related rules as legitimate. On the contrary, we found an array of strong reactions to the imposed rules of RNP and the ways in which they are being enforced (Supplementary Material).

Even though some individuals in a few communities may gain some short-term benefits, the majority of our interviewees express dissatisfaction with the PA. Local reactions range from passive denial of problems, and fear to challenge the authorities, to active attempts to negotiate with the PA authorities or intentionally disobeying the rules. MNP is facing even direct opposition in the form of armed conflicts (Expert interview 1) in the areas that we were not able to visit, the latter for obvious safety reasons.

Drawing from the multitude of reactions that the current top-down conservation strategy triggers in RNP, we see yet another case of local community subordination, and a power dynamic where local people are too afraid to speak up or to try to influence change. The lack of means to influence or forums to discuss makes local people feel powerless and a part of them become passive and seem to opt for denying some problems rather than trying to change them. A similar hierarchical power structure can be seen in the donor–recipient relationship of the development programs and sporadic employment offered to communities by MNP. Decades of supervision and assistance have led many community members to passively await and expect outside intervention to solve their problems for them, rather than initiate solutions themselves. Over the years, the development projects that MNP and others have offered to local communities have been punctual, targeted, and short-term, creating few sustainable impacts

and unevenly distributed benefits among villages, as explained by the MNP authority and the representatives of the Association of Guides of RNP (Expert interviews 3 and 4). Communities have come to expect financial aid and employment from MNP, revealing a situation of dependence. Furthermore, the MNP authority stated that the lack of trust that local communities have towards MNP is one of the biggest challenges for conservation.

The most positive perceptions on cooperation with MNP were in Vohiparara, which is also the only village with its own designated community forest. On the one hand, the villagers in Vohiparara are actively involved with conservation activities, have personal contacts with MNP staff, and speak proudly of the good relations with MNP and the help they have received. Yet, on the other hand, they tell about the ongoing conflict with MNP over crayfish catching: they would like to catch crayfish inside the protected area while the population in their own forest is recovering (and ideally alternate between the two in the long-term future, to keep both populations stable). The propositions by local community members for solving the problem included founding a community association for regulating crayfish catching and reporting to MNP. This concrete example reflects a willingness to take initiative, something which this study did not find in the other study villages.

DISCUSSION

Despite the official "co-management policy" of MNP (MNP 2014), some communities of Ranomafana region report that they are seldom recognised or treated as critically important partners in conservation. This has important consequences on the relationships between MNP and local communities, as well as on the legitimacy of the PA as a whole, and hence also the ultimate likelihood of successful conservation outcomes in the area.

Our findings are in line with previous research in the area (e.g., Korhonen 2006), firstly in that the conservation restrictions imposed by MNP and the *Chef Forestier* have hit the local communities hard, especially those who were already marginalized, i.e., remote, landless, and asset-poor (Kari and Korhonen-Kurki 2013). Secondly, long-term vulnerability threatens to push these villagers further into the margins of society, with development projects doing little if anything to improve their situation (Peters 1999). Ecotourism has provided employment only for a few, having little effect on local livelihoods (Sarrasin 2013). Consequently, local vulnerability is on the increase and traditional institutions of natural resource management are breaking down (Jones et al. 2008) – both processes accelerating unsustainable land-use practices.

Our interview data show that the imposed rules and regulations and the authorities enforcing them are mostly seen as illegitimate in the eyes of local communities, similar to other studies (also Peters 1999, Kull 2002). As we have shown above, the reactions to top-down governance are varied and have already led to mistrust and even direct opposition on behalf of local villagers. In parallel, decades of unsustainable development projects and insufficient compensation have led to scepticism. The attempted development projects, environmental awareness raising, and attempts to involve local people in conservation by giving them work in patrolling are all carried out in this context of confused and often even resentful feelings towards the PA and its agents. On one hand, local communities are accustomed to wait for outside intervention and financial aid while, on the other hand, as long as communication is hampered and local communities' rights overlooked, the latter find it hard to trust outside interventions, let alone take ownership of them. Similarly, as long as local traditional management practices and culture are disregarded, any externally initiated and imposed projects are likely to be held as just that: external and unlikely to result in genuine partnership or mutual understandings.

Taking into account all the above, conservation policy would benefit from embracing a more legitimate and representative form of governance – one that the local communities approve of and respect. This requires a commitment to social justice (Fortwangler 2003) and conservationists would do well to take advantage of the theory of environmental justice and adopt its three main principles: (i) equity of risks and benefits, (ii) recognition of rights, and (iii) participation in decision-making (Schlosberg 2013). The MNP authority we interviewed claimed to understand the lack of trust held by local communities due to the insufficient compensation they receive, but did not see its relation to the lack of recognition or participation given to local communities by authorities. The need to improve communication (as stressed by many local interviewees) was not raised as a concern by the MNP authority – nor was any possibility of increasing local participation or ownership. The MNP representative did stress the importance of collaboration with local communities, but only mentioned employment of local people in patrolling activities as a means for doing so.

Local involvement in the patrolling of the PA has not created a partnership between MNP and local communities and cannot be used as an indicator of co-management, contrary to the anticipation of MNP. However it does create new realities on ground. Gezon (2006) shows a similar dynamic in an Antankarana community neighbouring a PA in the northern Madagascar. The community members who are hired by conservation authorities face a situation where they have commitments to multiple, conflicting sources of authority, from the formal legislation and foreign conservation norms to local kinship ties. Ultimately, CLP members have to choose between these commitments. In some cases, turning against members of their own or neighbouring communities, can provide individual short-term benefits, but at the cost of social cohesion and solidarity. In other words, those with additional sources of income (e.g., from work in the CLP) and thus with more options to gain their living can turn the "wrong-doers" in. The so-called "criminals" on the other hand are mostly people who are driven to illegal activities because of extreme poverty and desperation, although in some instances also due to resentment towards MNP (see also e.g., Twinamatsiko et al. 2014). This dynamic enforces the existing inequalities in and among local communities, pushing the already less-endowed individuals and households further into the margins of the society (see also Brockington 2004). It also creates tensions and fear of revenge among villagers, as well as between villages and park managers, and increases the overall underlying insecurity experienced by the local villagers.

Another point of concern is that of local natural resources management and the possibilities it could offer for cooperation to achieve both conservation goals and social sustainability. Scholars specialised in the topic have suggested that the integration of traditional norms in conservation in post-colonial contexts is key to providing non-costly, voluntary, and respectful conservation approaches (Colding and Folke 2001). Yet, at least according to some of our interviewed local experts there is no such traditional, sustainable natural resources management system in place in the

context of RNP.

Based on our village-level data, however, we found that there still are at least some specific fady (i.e., local taboos) regulating the use of certain species. As has been noted elsewhere, traditional taboos rarely originate from attempts to sustainably manage natural resources (Berkes 2004, Jones et al. 2008) and indeed, the interviewees do not see fady as having much to do with conservation or natural resources management (see also Osei-Tutu et al. 2014). As Ostrom (1990) has pointed out in her influential work on local institutions, the maintenance of local informal institutions (for regulating the use of land and species sustainably and equitably among community members) depends on the recognition of local management authority. One cannot assume that a set of local management institutions would be maintained if and when they are rendered irrelevant or unnecessary due to the management authority being taken up by central government, as has been the case in RNP.

In addition to the national laws, traditional natural resources management systems are further replaced by environmental awareness raising that is based on scientific and neoliberal world views (as found in other studies, e.g., Jones et al. 2008, Hanson 2012, Miller et al. 2014). In this discourse, local knowledge is regarded as something irrelevant, something that does not overlap with or contribute to the conservation laws, and the local people are thus forced to see themselves as a threat to the environment. As Igoe and Brockington (2007) conclude, this kind of disrespect, dismantling of local natural resources management traditions and criminalisation of local livelihoods compromise the very citizenship of local communities.

This, however, does not mean that the local communities cease to influence conservation. On the contrary, we witnessed a lively debate on land-use practices within and among local communities and with a range of external actors. Our study also provides evidence for how a community – in this case Vohiparara – was able to take a more active role in managing a forest area despite the PA restrictions. On the one hand, the interviewees in Vohiparara speak proudly of the good relations with MNP and the help they have received, on the other hand they tell about the ongoing conflict with MNP over crayfish catching that they attempt to solve. What might have given this community more initiative than other communities lay beyond the scope of this research. However, one explanation might be the historical opposition and relation vis-à-vis MNP, which might have led to a more frequent, prioritised and eventually fluent communication between the community and MNP. This, in turn has possibly led to stronger community self-esteem, more courage and skills to confront problems, and therefore overall a more active community. This question cannot be answered based on the available data but it poses a fundamental and important question for future research attempting to investigate ways for more bottom-up initiative, and for promoting stronger and more equitable and genuine partnerships between local communities and national park (and other) authorities.

LIMITATIONS OF THE STUDY. The sample of local communities examined in this study are located within a day's walk from the main road and relatively close to the town of Ranomafana where the PA administration is based. Therefore, we can expect these communities to be more exposed to conservation authorities, better aware of MNP and its conservation strategies, and also at the receiving end of more environmental education and development programs than the more remote villages. Considering this, we find it alarming that even in our sample villages our informants claimed that there is no communication or negotiation with MNP.

Another limitation is the small sample size of interviewees. One of the main remarks of our study is the variety of different attitudes and reactions to conservation policies even within a community. While the answers of the interviewees started to repeat themselves indicating reaching the saturation point – at least in some of the study communities – we can still assume that having more data from each village could have revealed even more variety and social dynamics.

Choosing only villages near Ranomafana town was not our initial intention for this study. However, we were forced to leave out more remote villages due to logistical and temporal limitations and also due to some unexpected political events of unrest that prohibited us from going to certain areas. We acknowledge that having left out some of the more remote villages brings a geographical bias to the study, and also limits the range of information and characteristics that we would likely have obtained had we included them. For instance, our study villages have far better access to markets, which almost certainly plays a key role in determining livelihood opportunities and therefore also the types and levels of pressures placed on natural resources.

CONCLUSION

Our study examined institutional arrangements and community involvement of biodiversity conservation in Ranomafana National Park, with the aim of assessing local communities' involvement and initiative in conservation planning and management. We identified several tensions that exist between conservation authorities and local communities, as found elsewhere, also in continental Africa (Pyhälä et al 2016). The analysis of data gathered in the communities around RNP reveals that natural resource management takes place within a complex set of formal and informal institutions and sources of authority and dynamics among different social groups and actors at many levels. Conservation policies provoke a wide range of diverse local reactions, affecting the extent to which communities are willing (or able) to cooperate with conservation authorities.

It is evident that the historical oppression of communities around Ranomafana has resulted in a burden that challenges any new and more participatory conservation initiatives in the area. This burden influences both sides, i.e., communities and authorities. Local communities are sceptical of new conservation and development initiatives and therefore try to take all the material benefit from them while they last rather than self-organise or design structures for long-term sustainability themselves, let alone take ownership of the projects. Meanwhile, conservation authorities continue to blame local people's ignorance for the continuing deforestation and are reluctant to handover any trust or responsibility to them – despite local pro-conservation interests and practices. This, in turn, means that the so called "co-management" effort, as well as any environmental awareness raising, is likely to be conducted in a non-genuine manner, and therefore likely to only further exacerbate feelings of resentment among local communities. The result is a vicious cycle of mistrust and disrespect on both sides which, over time and generations, is difficult to break.

While community participation is critical, our results indicate that communities are rarely harmonious, homogeneous units and therefore participatory conservation policies and related development projects also do not automatically treat all community members equally or address inter-community problems, as other scholars have also pointed out (Agrawal and Gibson 1999, Leach et al. 1999, Castro and Neilson 2001). As Gezon (2006) argues, conservation projects can either reinforce existing power asymmetries or empower marginalised segments of the population. Our results seem to support the former, resulting in the further subordination and marginalisation of the already weakest social groups. MNP and all development and conservation actors should take this into account when planning and executing their projects, as the unequal effects threaten both social and ecological outcomes of existing policy. If current conservation and development strategies claim to aim at enhancing local livelihoods, they might do better if they prioritised targeting the poorest of the society, i.e., the ones most dependent on forest resources and therefore most easily driven to carry out sporadic illegal activities in the PA.

This case study strongly supports the already existing literature arguing against top-down conservation models in that they fail to support well-being and equity of local communities and to gain community approval. On the other hand, it also shows evidence of how the PA–community relationship can be different, especially if set in a more positive and constructive tone, as we found in one of our case study villages, where villagers have managed to keep their own community forest and seem to actively cooperate with and challenge MNP. We urge further research to look closer at these dynamics, and particularly address the question of why some communities (like Vohiparara) hold and act upon more self-initiative than other communities.

Empowerment of local communities to take initiative and to self-organise for better management of their natural resources requires some authority over those resources (Ostrom et al. 1999). Where that authority lies is perhaps the key questions, and the results of our study indicate that at least some degree of autonomy could boost community self-esteem, self-initiative, interest and ownership, and thereby also community self-organisation. Only once communities have met conservation authorities at such a half-way point can a real mutual partnership even be conceived.

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SUPPLEMENTARY MATERIAL.

Available online only.

Table S1. Summary of the data gathered in November–December 2014.

Table S2. Local reactions to top-down rules.

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Barking up the right tree: Understanding local attitudes towards dogs in villages surrounding Ranomafana National Park, Madagascar can benefit applied conservation

Kim Valenta[I], Joseph A. Gettinger-Larson[II], Colin A. Chapman[I] and Zachary J. Farris[III]

Correspondence:
Kim Valenta
Department of Anthropology, McGill University
Montréal, Quebec H3A 0G4, Canada
Email: valentakim@gmail.com

ABSTRACT

Exotic carnivores, particularly feral and domestic dogs, represent a serious threat to Madagascar's endemic fauna. We obtained information from the local community about dogs in villages in and around Ranomafana National Park (RNP), Madagascar. Surveys were conducted (N=359) to assess local opinions of dogs, reasons for owning dogs, and the willingness of dog owners to participate in spay/neuter/vaccine programs. Of surveyed individuals without dogs (N=211), 58.9% of respondents reported negative feelings towards free-roaming dogs, with only 1% of respondents identifying free-roaming dogs as a positive aspect of village life. Of individuals with dogs (N=148), 8.1% of respondents reported using their dog for hunting, and 41.2% reported that their dog had killed at least one wild animal, with 11.8% reporting that this occurred on a weekly basis. Villagers approve of spay/neuter/vaccine programs and 90.3% of respondents with dogs state they would use them if freely available. The interest in veterinary services combined with a generally negative attitude towards free-roaming dogs indicates that a spay/neuter/vaccine program would be an effective means of controlling dog populations.

RÉSUMÉ

Les carnivores exotiques, particulièrement les chiens domestiques et ceux retournés à l'état sauvage, représentent une menace sérieuse pour la faune endémique de Madagascar. Nous avons récolté des informations auprès des communautés riveraines sur les chiens vivant dans les villages et autour du Parc National de Ranomafana (RNP) au sud-est de Madagascar. Nous avons mené des enquêtes (N=359) afin d'évaluer les avis de la communauté locale sur les chiens, les raisons pour lesquelles les gens possèdent ces animaux et la volonté des propriétaires pour s'engager dans un programme de stérilisation/vaccination canine. Les villageois qui ne possédaient pas de chiens (N=211) représentaient 58,9 % des personnes interrogées ; ils ont rapporté avoir des sentiments négatifs envers les chiens errants et seulement 1 % des personnes interrogées ont vu un aspect positif pour la vie du village dans les chiens errants. Parmi les propriétaires de chiens (N=148), 8,1 % des personnes interrogées ont rapporté utiliser leur chien pour la chasse et 41,2% des personnes interrogées indiquent que leur chien a déjà tué au moins un animal sauvage, dont 11,8 % rapportant que cela arrivait toutes les semaines. Les villageois approuvent le programme de stérilisation/vaccination canine et 90,3 % des propriétaires de chiens y auraient volontiers recours si celui-ci était gratuit et librement disponible.

INTRODUCTION

The endemic wildlife of Madagascar, particularly its diverse lemur species, are a top conservation priority due to widespread anthropogenic disturbance, including forest loss, fragmentation, bushmeat hunting, and exotic species invasion (Ganzhorn et al. 2001, Ratsimbazafy et al. 2013). Exotic carnivores, particularly feral and/or domestic dogs represent a serious threat to wildlife worldwide given their ability to act as predators, disease vectors, and to influence trophic dynamics (Barcala 2009, Vanak and Gompper 2009, Young et al. 2011, Weston and Stankowich 2013, Ritchie et al. 2014, Farris et al. 2015a). Recent research in Madagascar has highlighted the ability of these exotic carnivores to negatively affect native wildlife, including altering temporal activity patterns (Gerber et al. 2012a, Farris et al. 2015b) and spatial distribution (Farris et al. 2015c) and reducing the probability of occupancy and detection for native carnivores (Gerber et al. 2012b, Farris et al. 2015b). In addition, Farris et al. (2014) highlighted the negative interactions between exotic carnivores and lemurs (*Microcebus rufus*) across contiguous and fragmented forests, and point to a striking decrease in lemur occupancy at sites where exotic carni-

I Department of Anthropology, McGill University, Montréal, Quebec H3A 0G4, Canada
II Department of Ecology and Evolutionary Biology, University of Tennessee, Knoxville, TN 37996, United States
III Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, VA 24061, United States
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vore presence is high. With increasing habitat fragmentation, endemic lemur populations will be simultaneously affected by increased predation and declining habitat quality. Dogs may pose a great threat to Madagascar's endemic primates as dog owners use dogs for hunting wildlife, and free-roaming and feral dogs may venture into the forest to hunt on their own. Dogs also threaten lemurs through competition interference, and may transfer zoonotic diseases to endemic primates (Butler and du Toit 2002, Butler et al. 2004, Manor and Saltz 2004, Galetti and Sazima 2006, Lenth et al. 2008, Lacerda et al. 2009, Vanak and Gompper 2009, Young et al. 2011). While many dogs that enter Madagascar's forests can be considered to be feral, i.e., unowned and unhabituated to humans, many others are owned by individuals, but are not restrained. Such dogs are a threat to the endangered lemurs and further compromise their conservation, especially when they inhabit villages within or adjacent to parks.

The goal of this study was to obtain information from the local community about feral and free-roaming dogs in villages in and around Ranomafana National Park, Madagascar, a protected area comprising 416 km^2 of submontane rainforest. The park contains many threatened lemur species including the golden bamboo lemur (*Hapalemur aureus*), greater bamboo lemur (*Prolemur simus*), black and white ruffed lemur (*Varecia variegata variegata*), and Milne-Edwards sifakas (*Propithecus diadema edwardsi*). Specifically, we wanted to obtain information about (i) how many feral and free-roaming dogs there were in the area – thus the magnitude of the threat to the endemic fauna and (ii) their potential to hunt inside the national park. It should be cautioned that the information that we gathered are the impressions of the local community and contain potential sources of error or bias. Most importantly if local residents are entering the park with their dogs to obtain natural resources and know that this is an illegal activity that they should not be engaging in, they will most likely underreport it (Gavin et al. 2009). They may also know that they should not be allowing their dogs to enter the park, if there is a risk that they kill protected wildlife. As a result, responses to some of our questions should be considered as minimum estimates and we consider this bias further in the discussion.

METHODS

STUDY SITE. Surveys took place in four villages: Ambatolahy, Ambodiaviavy, Ranomafana, and Vohiparara. All villages border Ranomafana National Park (RNP), southeastern Madagascar (E 047° 20', S 21° 16'), and all villages are within five km of one another, along the only paved road in the region. RNP ranges in altitude from 500 to 1,500 m (Wright 1995). The rainfall varies from 2,300 to 4,000 mm per year, with most precipitation occurring between December and March. Average annual temperature is 21°C, with lowest temperatures from June to September (0–12°C) (Pochron et al. 2005).

METHODOLOGY. Over two-month field seasons in June 2014 and June 2015, we collected survey data by interviewing villagers. Methods used for data collection included the use of filter questions (Rennekamp and Nall 2000) to establish essential survey questions and gain focused responses, (e.g., Question 4: 'Has your dog ever killed wildlife?'; if 'Yes' go to Question 5: 'What species of wildlife has your dog killed?'; if 'No' go to Question 6). Surveys took about ten minutes to conduct and were comprised of up to 25 possible questions.

In each village, we collaborated with the village president, the village mayor and other elders, asking them to explain the goals of a free spay/neuter/vaccine initiative (www.maddoginitiative.com) to villagers and the accompanying survey questionnaires. Elders were asked to explain that free spay/neuter surgeries would be offered at the clinic, along with rabies vaccinations, de-worming, and medical treatment for sick or injured dogs. Surveys began only after receiving permission from the village president, mayor, and elders.

There were two categories of participants: (i) all dog owners who brought their dogs to the free mobile veterinary clinic providing spay/neuter/vaccine services as part of a spay/neuter/vaccine initiative to reduce feral and free-roaming dog populations were asked to participate in the survey (N=148). (ii) Villagers without dogs were randomly asked to participate in surveys by local team members. Surveys were administered by two Malagasy veterinary professionals in the local Malagasy dialect (N=211). We calculated descriptive statistics separately for individuals without dogs and individuals with dogs, since survey questions varied between these groups. Since villages were all close to one another and connected by road, we pooled all data for analyses.

All research adhered to the laws of Madagascar where the research took place, and took place under research permits issued by the Government of Madagascar and Madagascar National Parks (permit number: MIE-1594001609).

RESULTS AND DISCUSSION

Of surveyed individuals without dogs (N=211), most respondents reported generally negative feelings about the presence of free-roaming and feral dogs in their villages. 58.9% of respondents identified feral and free-roaming dogs as a problem or nuisance, 40.1% of respondents were neutral about their presence, and only 1% of respondents identified the presence of free-roaming dogs in villages as a positive aspect of village life. Similarly, 72.3% of villagers reported that life in the village would be better in the absence of feral and free-roaming dogs. In terms of the treatment of feral and free-roaming dogs, 16.5% of non-dog-owning respondents reported feeding free-roaming and feral dogs, while the remaining 83.5% reported either deterring dogs from their properties, ignoring them, or in 3.4% of cases, killing them.

Of individuals with dogs (N=148), the mean number of dogs per household was 1.57 (range = 1–14, S.D. = 1.49). Respondents cited personal and property protection as the number one reason for owning a dog (51.4%), followed by a combination of companionship and protection (29.7%). Interestingly, the remainder of respondents identified hunting as at least one of the reasons for owning a dog, either hunting alone (1.4%) or in conjunction with protection (3.4%), companionship (1.4%), or both (2.0%). As previously stated, since hunting is an illegal activity, the number of villagers that hunt with their dogs is likely higher.

In total, 6.8% of respondents reported purchasing their dogs, while the remaining 93.2% adopted dogs as strays, puppies, or offspring of previous dogs. Of those owners whose dogs produced offspring, respondents reported yearly litters in 52.4% of cases, with the remaining owners reporting litters less frequent than once per year. Respondents reported that in 45.2% of those litters, some or all of the puppies were either dead or lost. 38.1% of respondents reported giving puppies away to friends and neighbors who adopted them, yet only 2.4% of respondents reported adop-

ting at least one of the puppies themselves. Amongst dog owners, attitudes towards ownership varied widely. While 95.9% of respondents reported feeding their dogs food scraps (primarily rice, cassava, and bones), and 35.6% of respondents reported that their dog(s) spent less than 1 hour per day away from them, 4.1% of respondents reported not feeding their dog(s), and 6.2% of respondents reported that their dog spent the entire day away (Figure 1).

In terms of dog predation on other animals, there is a strong divide in reported predation on domestic versus wild species. Only 15.8% of respondents reported that their dog had killed domestic animals, with only 4.3% of those respondents identifying domestic animal predation occurring more frequently than once a month. This finding may not be completely accurate as respondents may avoid taking ownership of responsibility of their pet killing neighbors' livestock. In 91.2% of cases where respondents reported the killing of one or more domestic animals by their dogs, these were identified as chickens and/or ducks, with one reported pig predation, and one reported dog killing.

In terms of dog predation on wild animals, numbers reported are substantially higher. In contrast to the low reported number of domestic animal predation by dogs (15.8%), 41.2% of respondents reported that their dog had killed at least one wild animal, with 11.8% of those respondents reporting that their dog predating wild animals occurred more than once per week. Overwhelmingly, dogs were reported to prey on tenrecs (24.1%), small, endemic insectivores of the family Tenrecidae, or tenrecs in addition to other small animals (rodents, frogs, birds, snakes – 32.7%). 34.5% of respondents identified their dogs as killing wild rodents, frogs, birds and snakes, but not tenrecs, and 5.2% of respondents reported their dog killing introduced bushpigs (*Potamochoerus larvatus*). At least two dog owners reported their dogs having successfully predated fossa (*Cryptoprocta ferox*), Madagascar's largest native carnivore (Figure 2). While protection is the primary reason respondents report for owning dogs, 41.2% of respondents report travelling with their dog(s) into the forest adjacent to villages (i.e., RNP) at least once weekly (Figure 3).

CONCLUSION

Overall, free-roaming dogs are very much a part of the life of villagers living in and around RNP, and village surveys support previous camera trapping surveys which indicate that dogs may be predating wild animals or competitively excluding them (Gerber et al. 2012a,b; Farris et al. 2015a,b,c). However, despite the ubiquity of free-roaming and feral dogs in villages, there is generally a willingness to see dog numbers reduced or controlled, with only 1% of non-owner respondents identifying dog presence in villages as positive. Even amongst dog owners, 66% of respondents identified free-roaming dogs as a nuisance or problem, while the remaining 44% were neutral, and none expressed positive feelings towards free-roaming dogs.

In terms of both dog welfare and potentially reducing dog population numbers, villagers living in and around RNP generally approve of spay/neuter/vaccine programs and are very willing to participate in them, with 90.3% of respondents with dogs stating that they would use veterinary (including spay/neuter) services for their dogs were they freely available. Only four respondents of 145 (2.8%) said they would not make use of free veterinary services if available. While our results do not allow us to infer the attitudes of dog owners across Madagascar, this survey may be useful as a means of establishing the suitability and potential success of spay/neuter/vaccination programs in other areas of Madagascar.

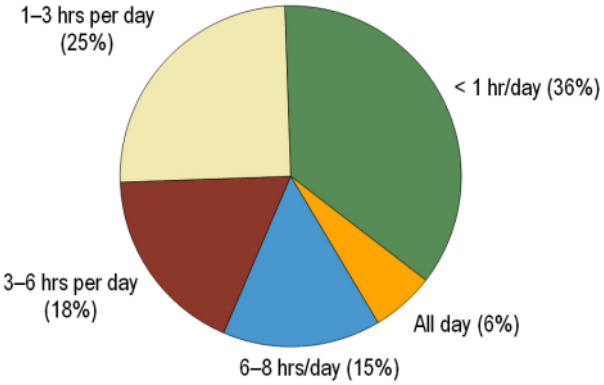

Figure 1. Reported hours per day that dogs spend away from their owners (N=145).

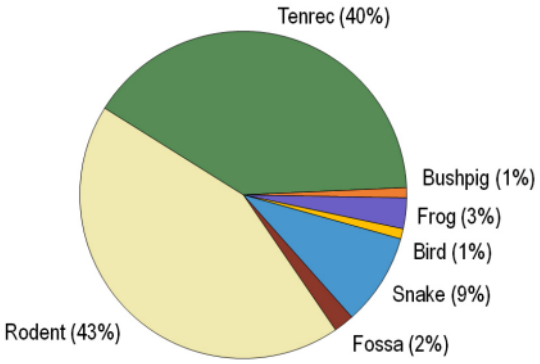

Figure 2. Reported dog predation on wild animals. Of the 58 respondents who confirmed wildlife predation by their dogs, many of these reported multiple species that were predated by dogs. This figure represents 88 reported predation events.

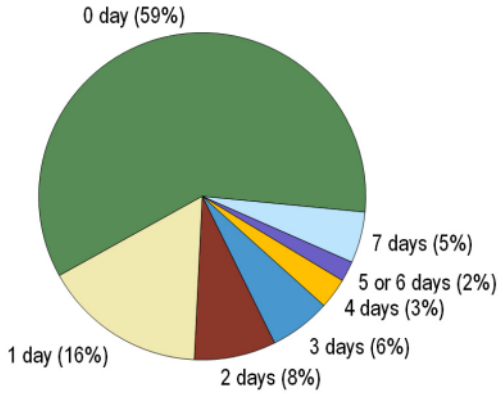

Figure 3. Number of days per week that respondents reported traveling into the forest with their dogs (N=147).

The interest in veterinary services by the majority of respondents combined with a generally negative attitude of non-dog-owners towards free-roaming dogs indicates that a spay/neuter/vaccine program in these areas should be a highly effective means of controlling dog populations. In addition, killing of local dogs by owners and non-owners is rare, suggesting capture-kill efforts would likely not be popular or seen as a viable option across this region. Thus, the way forward is likely through spay/neuter/vaccine programs, in addition to increased anti-hunting enforcement. In this region, hunting is tantamount to poaching because the wild, endemic animals are found within the

bounds of a national park, and in many cases, are of protected species. Additionally, targeted education programs coupled with these services are necessary, given that almost half of dog-owners report traveling with their dogs into the forest. The presence of dogs within the forest has been shown to have numerous negative effects on native wildlife and the most effective measure to diminish or eliminate these effects is to curb this practice.

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Two sides to every coin: farmers' perceptions of mining in the Maningory watershed, Madagascar

Natasha Stoudmann[I], Claude Garcia[I, II], Ihoby H. Randriamalala[III], Vanessa A. G. Rakotomalala[III], B. Ramamonjisoa[IV]

Correspondence:
Natasha Stoudmann
Forest Management and Development, Department of Environmental Sciences,
Swiss Federal Institute of Technology Zurich
8092 Zurich, Switzerland
Email: n.stoudmann@hotmail.com

ABSTRACT

An increasing share of Madagascar's population is dependent on artisanal and small-scale mining (AMS) as a source of livelihood. However, this unregulated activity has numerous repercussions on the miners themselves and on neighboring communities. This study explores the perception of mining of those indirectly affected by its growing presence. Farmers and fishers were interviewed to better understand the perceived impacts of AMS on communities situated at varying distances from mining activity. The results of this first qualitative study show that positive or negative perception may be linked to geographical distance to mines. Those living in mining-communities may reap more benefits from the proximity than those living further away, who mainly experience negative effects. The results from this small sample will need to further be empirically tested.

RÉSUMÉ

Une part croissante de la population de Madagascar tire l'essentiel de ses moyens de subsistance de l'exploitation minière artisanale et à petite échelle. Cependant, cette activité non-réglementée a de nombreuses répercussions sur les mineurs eux-mêmes et sur les communautés voisines. Cette étude explore comment les riverains indirectement touchés perçoivent l'exploitation minière qu'ils rencontrent de plus en plus souvent. Des paysans et des pêcheurs de communautés basées à des distances variées des activités minières ont été interviewés afin de mieux comprendre les impacts perçus de l'exploitation minière artisanale. Les résultats de cette première étude qualitative montrent que des perceptions positives ou négatives pourraient être liées à la distance entre les lieux de vie des communautés et les mines. Les habitants vivant au sein de communautés minières pourraient tirer plus de profit de cette proximité que ceux vivant plus loin et ressentant principalement des effets négatifs. Les résultats de ce premier échantillon devront être vérifiés de manière empirique.

INTRODUCTION

The extraction of Madagascar's mineral resources has been gaining momentum in the last few decades (Sarrasin 2007, Huff 2016, INSTAT 2016), attracting both large scale mining companies as well as an increasing number of fortune seekers looking for gems, forming a considerable large unregulated mining sector. These artisanal miners perform this activity without long-term planning and use simple extraction techniques (Hinton et al. 2003, Cardiff and Andriamanalina 2007, Gorenflo et al. 2011). Although the impacts of large scale mining (LSM) operations have often been described (Harbinson 2007, Sarrasin 2007, Ballet and Randrianalijaona 2014, Randriamamonjy et al. 2015), the social, economic and environmental impacts of artisanal and small scale mining (ASM) are often not so well documented and subject to increasing discussions due to its informal and often illegal nature (Hinton et al. 2003, Duffy 2007, Tilghman et al. 2007, Cook and Healy 2012). Although environmental and mining permits allowing ASM operations are issued by the authorities in Madagascar, much of the mining takes place without such permits having been obtained, with illegal extraction in protected areas being of key concern (Cook and Healy 2012, World Bank 2013). Previously depicted as an activity practiced by individuals to earn large amounts of cash in short amounts of time (World Bank 2005), there is a growing consensus surrounding the link between growth of artisanal mining and poverty, with ASM often being amongst the few alternative forms of livelihood diversification available to these individuals (Siegel and Veiga 2010, Canavesio 2014, Hilson 2016). It seems that more than opportunistic, engagement in ASM is more a result of lack of options, rather than a high risk/high reward strategy (Hilson 2010, Banchirigah and Hilson 2010, Canavesio 2014, Hilson 2016). Engaging in ASM often lead to increasing vulnerability, not the opposite (Cartier 2009).

The impacts of mining on Madagascar's natural environment are wide-ranging, from landscape changes, water pollution, to hunting of already scares animals (Tilghman et al. 2007, Gorenflo

I Forest Management and Development, Department of Environmental Sciences, Swiss Federal Institute of Technology Zurich, 8092 Zurich, Switzerland
II Forêts et Sociétés, CIRAD, Montpellier, France
III Madagascar Wildlife Conservation, Ambatondrazaka, Madagascar
IV University of Antananarivo, School of Agronomy, Water and Forest Department, BP 175, Antananarivo 101, Madagascar

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et al. 2011), although it has been argued that impacts of ASM are restricted due to the localised nature of extraction (Cartier 2009). However, illegal mining taking place within national parks and other protected areas leading to the deterioration of local ecosystems is a source of concern for authorities and conservationists (Walsh 2004, Duffy 2005, Walsh 2013, Huff 2016).

Unlike large scale mining that has been supported by the Malagasy Government and the World Bank, ASM has commonly been negatively depicted by these institutions (World Bank 2005, Canavesio 2014). Although the World Bank (2015) is changing its standpoint, pushing for the formalisation of the ASM sector, these attempts have largely been put on the back burner by the new government instated in 2013 (Huff 2016).

Little information is available on the perception of ASM within local populations, and about the impacts that farmers – being the main resource users of Madagascar (Kull 2012, Rakotoarisoa et al. 2015) – view as stemming from this activity. Our study took place in the Maningory watershed, encompassing part of the Alaotra-Mangoro and Analanjirofo regions (Figure 1), from 27 October to 10 December 2015. As well as being agricultural hubs of the country (Andrianandrasana et al. 2005, Alizany et al. 2010), both regions are home to LSM and ASM activities, attracting an inflow of individuals and contributing to an increasing population (Raharinirina 2013, Rendigs et al. 2015, INSTAT 2016). We were interested in gaining a better understanding of the way farmers and fishers, two of the main resource users of these regions (Katila et al. 2014, Rakotoarisoa et al. 2015), experience mining. Our first research question focused on how these resource users perceive mining. Secondly, we were interested in identifying the personal consequences they perceive as stemming from ASM.

METHODOLOGY

Our three study sites (Figure 1) were the villages of Antanandava, Vohimarina and Vavatenina, representing a transect of the Maningory watershed and being at varying distances from mining activity, the most prominent locations often mentioned by participants being in the regions of Didy, Andilamena, and several small sites near or within Zahamena National Park (Figure 1). Due to the informal nature of the mining, information about exact distances to the sites was not available.

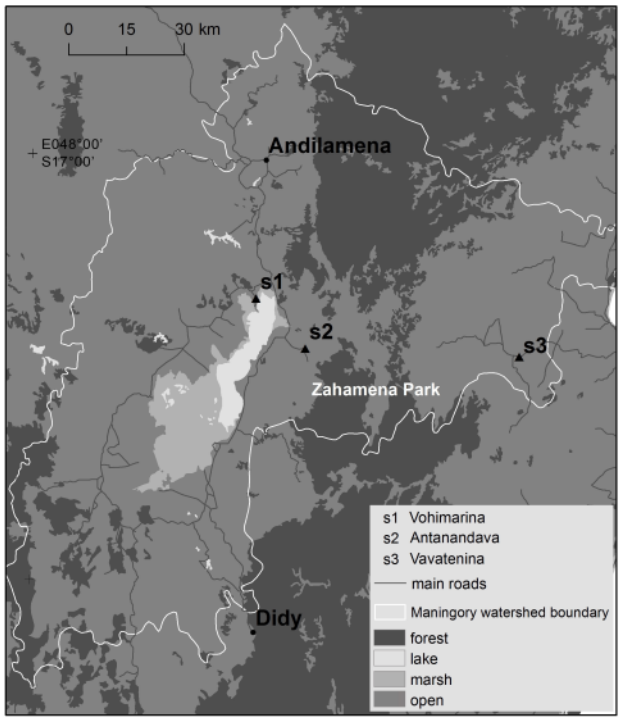

Figure 1. Delimitation of the Maningory watershed and location of the three study sites. Areas near Andilamena, Didy and Zahamena National Park are home to some of the most prominent mining sites in the region.

Participants were selected per their profession (farmer and/or fisher), i.e., individuals who do not depend on mining as their main source of income, and age (between 25 and 65), with the aim of having a balanced representation of men and women. The subject of mining was identified as being relevant to farmers during a series of six focus group discussions (Kitzinger 1994) conducted in the three study sites (Figure 1) and comprised of a total of 30 participants. Having obtained the consent to interview the participants (Wilmé et al. 2016), these focus groups explored the broad subject of change, where mining and the extent of its impacts were often discussed. The notes taken during the focus groups were translated from Malagasy into French by a member of the research team having facilitated the discussions (A.R.), before being discussed and verified with the other members. Following this first phase of focus groups, we conducted 30 semi-structured interviews in the three study sites (10 per village, with 40.0% female respondents overall and 13.3% fishers). Participants were firstly asked whether they saw mining in a positive or negative light. Secondly, they were asked about the consequences of mining for themselves and their community. Each interview was translated as soon as possible after having been conducted from Malagasy into French (A.R.). We used the binomial test to determine whether there were significant sex, age, or profession differences in positive and negative views.

RESULTS AND DISCUSSION

The qualitative results of this small sample (n=30) give an insight into farmers' perceptions and allow for the development of hypotheses that will need to be empirically tested. Although a quarter of participants perceived mining favourably, the remaining three-quarters strongly believed this activity had negative effects for themselves and their community. Only one participant had a mixed view about the activity, pointing out both positive and negative impacts. There were no significant gender, age, or profession differences in terms of positive or negative views.

The participants identified 16 consequences of mining activities (Figure 2). The two most mentioned impacts relate to environmental effects of mining (soil degradation and forest degradation), which indirectly affect farmers' livelihoods and yields, as put forward by a participant: "*(…) it leads to forest destruction which in turn leads to the absence of rain and waste covering fields, which leads to decreasing soil fertility*" (P10). Several participants further put forward its direct impact on agriculture, as many male farmers try their luck searching for gems, leading to fewer people working the fields and therefore less produce available on the market. Participants mentioned that the attractiveness of becoming wealthy very fast pushed certain youngsters to drop out of school to work in the mines, often without their parents' consent, as one participant explained: "*(…) children do not want to go to school anymore and drop out to go earn money at the mines*" (P25).

Positive aspects were identified by 26.7% of participants, the most often mentioned being the increase in farmers' standard of living, as villages close to mining activities experienced increasing inflows of people. One participant explained the impact mines

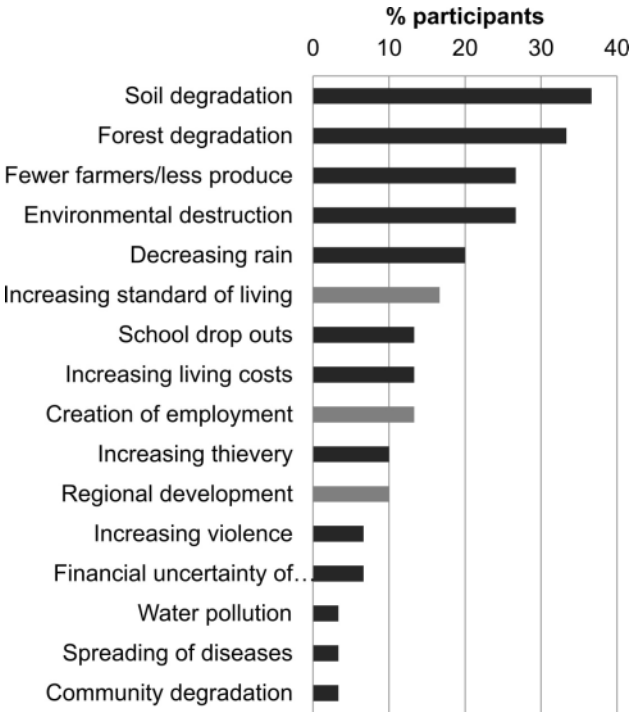

Figure 2. Consequences of mining identified by participants (n=30). Positive identified aspects are in grey.

have had on him by "*(…) the creation of work as a brick vendor, as there is an increasing number of people coming to the area*" (P04). This can lead to a larger customer base and increasing opportunities for farmers to earn extra income. At a larger scale, this can be linked to employment creation and regional development, put forward by one participant, as mining activity "*(…) increases my standard of living as my number of clients increases*" (P08).

Figure 3 illustrates the geographical distribution of the positive and negative views between the three study sites. The village of Antanandava showed the highest percentage of support, whereas Vavatenina the least. Although as previously stated exact distances to mines were not available, Antanandava is known for its proximity to mines and is the gateway to the Zahamena National Park (Figure 1), where rumours of gold mining are commonplace throughout the region, also having been mentioned by several participants.

The sample shows that there may be a geographical relation between support and opposition towards mining activities. We hypothesise that support or opposition to mining may be linked to a village's distance to the activity, with villages that are closer reaping more benefits such as larger client bases, whereas villages further away experience the negative impacts such as farmers leaving to go to the mines, without having any of the potential positive impacts reaching them. Mining communities, i.e. villages where a significant share of its population work in mining and where extracted commodities are sold (Cartier 2009), may therefore have more positive views of the activity than non-mining communities, where different – mostly negative – impacts of this activity are felt.

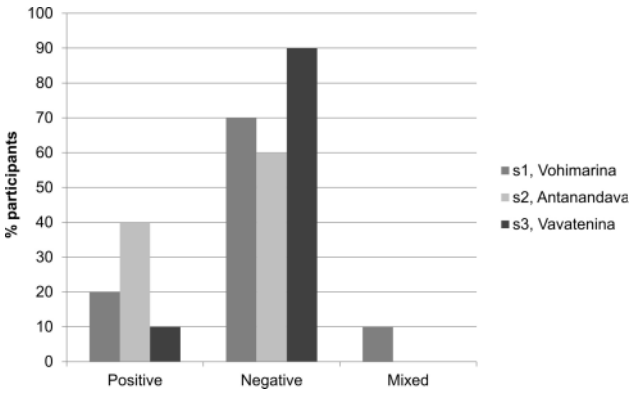

Figure 3. Geographical distribution of positive and negative views.

The consequences of mining identified by participants are closely linked to changes they generally see as affecting them, connected to environmental and agricultural issues affecting the livelihoods of these populations (Banchirigah and Hilson 2010, Rakotoarisoa 2015). Socio-economic impacts are also emphasised, although to a lesser extent. This could imply that when considering quality of life, farmers attribute most value to securing their livelihood (Scoones 1998), with other factors seen as being secondary to their well-being. Bebbington (1999) puts forward the importance of social capital relative to the other four capital assets – namely natural, human, cultural, and produced capital – stating that this asset plays a key role in determining rural people's livelihoods, in that it "facilitates forms of action that one would expect enhance peoples' livelihoods" (Bebbington 1999: 2037). In the case of mining, this could imply that the social interactions and assets derived from these, both for miners and for those living within the mining community, lead to improved livelihoods even if at the cost of for example natural capital. The increase in social capital could be brought about for example through increased interactions due to the flow of people coming and going through the village. Environmental issues will directly affect farmers' livelihoods, however farmers who are also indirectly benefiting from ASM – or directly if they partake in mining as a secondary activity – may have their natural capital assets decreased, but their access to another form of capital improved. Thus, although those whose livelihoods have improved through the development of this activity will perceive it favourably, those whose capitals and therefore livelihood have been negatively affected, even indirectly and/or from a distance, will have a negative stance towards the subject. These hypotheses would however need to be tested with a larger sample.

CONCLUSION

This first qualitative exploration of perception of ASM of those indirectly affected by it, also being the main resource users of the Maningory watershed, gives a first insight into how this activity may be unevenly affecting communities of these regions. Further research is needed to better understand how mining impacts the quality of life both of its workers and of mining community inhabitants working in the agricultural sector. Furthermore, little is known about the factors pushing farmers of the Alaotra to change their life-long trade and enter the mining sector – whether they do so as a form of opportunity to 'get rich quick', or out of necessity and on a long-term basis, as a form of diversification. It is first necessary to understand the nature of ASM and the perceptions of those living with and around it to gain a better understanding about how to potentially improve the management of this growing activity and its many consequences.

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We would like to thank the personnel of Madagascar Wildlife Conservation for their support throughout the fieldwork, as well as the participants for their time. A special thanks goes to Patrick O. Waeber for his comments on an early draft, as well as to the reviewers for their help in improving this piece. This work was supported by the Swiss Programme for Research on Global Issues for Development under the research grant IZ01Z0_146852.

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MADAGASCAR CONSERVATION & DEVELOPMENT INTERVIEW http://dx.doi.org/10.4314/mcd.v11i2.8

Madagascar's rosewood stocks – which way to go?

Derek Schuurman
Ndranto Razakamanarina
Sonja Hassold
Luke V. Zahner

Correspondence:
Journal Madagascar Conservation & Development
Anthropological Institute and Museum
University of Zurich
Winterthurerstrasse 190, 8057 Zurich, Switzerland
E-mail: info@journalmcd.net

For centuries, people around the globe have admired Rosewood. Malagasy rosewoods (*Dalbergia spp*.) are especially valued for their qualities. In recent years, illegal sourcing of rosewood escalated to unprecedented levels: this coincided with the political fallout from 2009-2013. The wood has been – and is - sourced mainly from protected areas in eastern Madagascar. Before being exported, timber is stockpiled, mostly in well-concealed localities. Despite an international ban on export and trading, the timber has been – and continues to – leave Madagascar. The species targeted are CITES listed, which means that trading them is forbidden. Most of the wood has been shipped to China, where demand for it is enormous. In 2011, stocks were estimated to be in excess of 500,000 tons. In 2013, the international community, spearheaded by the SADC were to prepare new presidential elections which were expected to put an end to the political and economic crisis of what is an increasingly beleaguered nation. In the same period, the World Bank implemented a project aimed at finding a solution of how to deal with the controversial rosewood stocks. At time of writing, this remains a topic of debate. Experts in a previous MCD interview suggested either to destroy the stocks in order to avoid further illegal sourcing of timber from protected areas, or to establish a timber bank of sorts. All agreed that selling the wood would be a double-edged sword: while it brings much- needed revenues to the empty coffers of the government, it may fuel and further increase demand for Rosewood. A noticeable and lengthy silence followed, with virtually no coverage in the national and international media. The World Bank project (#PO93271) comes to an end in December 2015: "all illegal precious woods stockpiles sized by Government have been audited and secured".

The journal MCD is asking the 2011 questions – four years later, and would like to give voice to some of the experts and practitioners involved in this rosewood crisis.

DEREK SCHUURMAN, ENGLAND

What do you think should the government do with its stockpiled rosewood, and why?

In an ideal world, I would advocate for the destruction of existing timber stocks. This would send a strong signal out to all parties involved in the supply and demand sides of the illegal trade in these hardwoods: as it has been established that the target species have been extirpated from outside of areas designated as protected, it follows that transportation and trade of such timber is illegal. However, it isn't so easy or straightforward. Firstly, nobody knows how much felled rosewood still remains concealed or unaccounted for. The country has a particularly difficult geography and a frail infrastructure. And it is one where corruption is rife. The criminal networks involved are backed by China and involve a network of Malagasy accomplices in all echelons of government. Madagascar would not want to upset its relations with China. Taking these factors into account, the alternative solution is the establishment of a 'wood bank', as has been discussed in the past. Once again however, such a process would more likely than not, be complicated and hindered by aforementioned variables, notably corruption.

Can the illegal logging and traffic of precious wood in Madagascar be stopped, and how?

There has to be political will on the part of the Malagasy government and also, cooperation on the part of the Chinese government. Without agreement from both sides, illegal trading of Malagasy rosewoods will not stop until the last trees have been felled. Given that the moratorium banning sourcing, transporting and trading of these timbers was declared in 2010 and that subsequently, these activities have been continuing unabated, the sensible approach would be for dialogue to be established with China, in hopes of having a ban declared on importing these timbers. If that is achievable, the rest will follow. (I do not see it working the other way around).

Please give in three key words, how you would improve this situation.

Transparency | foresight | negotiation

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NDRANTO RAZAKAMANARINA, ALLIANCE VOAHARY GASY, MADAGASCAR

Selon vous, que devrait faire le Gouvernement avec le bois de rose stocké, et pourquoi ?

Le gouvernement devrait assurer le transport des stocks de bois 'transportables' dans trois (maximum) lieux de stockage hautement sécurisés jusqu'à une date déterminée, et brûler les bois non transportables jusqu'à cette date limite devant le public. Il faudra conserver ces bois 'stockables' dans ces trois lieux de stockage hautement sécurisés jusqu'à l'obtention des autorisations de quota de vente par la CITES. Entre temps, il faudra autoriser les associations légales de sculpteurs de Madagascar à valoriser et bénéficier d'une partie déterminée des stocks. Il faudra mettre le stock restant en vente aux enchères publiques internationales tout en filtrant l'écoulement par rapport aux réseaux mafieux déjà identifiés (éviter la Chine?). Les fonds ainsi acquis devront servir au renforcement de la gouvernance du secteur (primes aux témoins, dénonciateurs, gardiens séquestres et agents de répression) et au développement durable des zones de prélèvement. Il va de soi que toutes ces mesures seront accompagnées d'un système sécurisant pour une haute protection de témoins assortie d'une prime de témoignage substantielle.

La coupe illégale et le trafic de bois précieux à Madagascar peuvent-ils être arrêtés et comment ?

La passivité ou l'inaction de l'État et des bailleurs de fonds qui continuent de fournir des financements tient de la complaisance, voire de la complicité face à l'ampleur et à l'impunité des trafics (Figure 1). Pour arrêter la coupe illégale, il faut inciter 'par tous les moyens imaginables' le Président de la République à s'engager personnellement et visiblement dans l'assainissement immédiat du trafic par trois indicateurs visibles : (i) Sanction à l'encontre de deux ou trois vrais barons récidivistes de la mafia ainsi que du personnel administratif inculpé et cela de manière exemplaire ; (ii) Engagement de la lutte contre la corruption et suivi transparent et public dans les trois secteurs de gouvernance hautement affectés, à savoir la justice, les forces armées et les collectivités décentralisées ; (iii) Développement concerté et mise en œuvre inclusive d'une vision sur 50 ans pour la gestion durable des ressources naturelles de Madagascar (bois précieux, mines et ressources halieutiques).

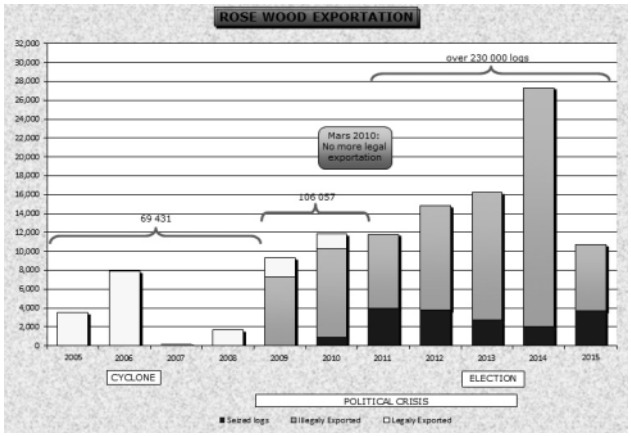

Figure 1. Exportations légales, illégales et saisies entre 2005 et 2015 (AVG et Fanamby).

En trois mots clefs, comment pourriez-vous améliorer la situation.

Déstockage | sanction | vision

Pour assurer conjointement une décentralisation du pouvoir et des moyens ainsi que la mise en œuvre rapide du programme de développement du pays en incluant la valorisation holistique du grand potentiel hydroélectrique qui permettra la création d'emplois, l'indépendance énergétique et l'assainissement de l'énergie bois.

SONJA HASSOLD, INSTITUTE OF INTEGRATIVE BIOLOGY,
ETH ZURICH, SWITZERLAND

What do you think should the government do with its stockpiled rosewood, and why?

Fact is that the rosewood stockpiles have been illegally logged, so whatever is decided, needs to account for that. I personally see a chance at this stage to develop a concept for the sustainable future use of Malagasy rosewood. Only with such a concept at hand we may decide what to do with the stockpiled rosewood. To develop such a concept we should decide how the future use, control, management and organization of Malagasy timber trade should look like. Precious timbers of Madagascar (rosewoods are by far not the only ones) can generate a valuable and sustainable income when managed and organised carefully. As a renewable resource I think these timbers may have great potential to play an important role in the future and are worth developing a long-term strategy for sustainable use that could reduce the pressure on protected forests. The genetic resources (e.g. seeds from different individuals of the same species and from different species) that are necessary to initiate such a project are still available to start with propagation of the economic interesting species but we need to start now, as with each loss of an adult tree the potential for collecting suitable seeds for cultivation is diminishing. Unfortunately in the case of Malagasy rosewoods (genus *Dalbergia*) we still do not know which species (botanically speaking) are illegally logged and traded and how severely they are therefore threatened. In order to identify the species that are most threatened through logging and to decide where to focus conservation efforts, we should analyse wood samples from the stockpiles with genetic methods, chemical component analysis, isotopes or wood anatomy. The scientific community therefore urgently needs access to samples from the stockpiles for identification purposes. With that in mind I personally think that the stockpiles should be kept safely for now and illegally harvested logs should continue to be seized, recorded and safely stored. The possibility of selling these stockpiles should only be discussed again once a detailed concept for the future sustainable use of Malagasy timber has been developed and agreed on. If then a decision is made to sell the stockpiles I would advice not to sell them all at once but in smaller portions so that the money can directly be invested in the different phases (see answer below) of the developed concept to initiate a visionary and sustainable long-term use of Malagasy rosewood.

Can the illegal logging and traffic of precious wood in Madagascar be stopped, and how?

I personally think that we should aim for a change of direction in the timber trade towards legal management and sustainability to generate money for future sustainable projects. For such a large-scale change to happen I think commitment and will are the most important drivers to successfully change this timber trade into a direction of sustainability. Having a clear step-by-step concept and strategy available to make the timber trade more sustainable might help to increase commitment and will. To develop and initiate such a sustainable concept for timber trade should in my opinion include discussions about how to control and ensure legality of timber in trade (e.g. improving the tagging system or using genetics and chemical component analysis), timber certification (e.g. based on genetics or forest concessions). It should also address questions about the best cultivation model, what is a suitable place to start in terms of environment, management and infrastructure, what are the best growth conditions and what infrastructure is needed. It is critical to carefully consider who develops a business and management plan for such a project, who could manage such a project, how to involve the local communities and which stakeholders should be involved in order to achieve a broadly accepted and sustainable agreement that includes not only conservation aspects but also the welfare of the local communities. The species of interest may be slow growing and therefore a project with different phases might be required. This could be achieved with mixed cultures as shown in projects in India that combine cultivation of timber species with fruit trees and coffee plants where fruits and coffee generate income within a few years. To establish a long-term project I think it is important to also support the education and training of involved people, as well as involve scientists to improve molecular identification systems and cultivation methods. I think with commitment, will and visionary thinking towards sustainability it is possible to stop illegal logging with careful planning, implementation and involvement of local communities.

Please give in three key words, how you would improve this situation.

Develop a concept for sustainable use of Malagasy rosewood

Accessibility of stockpile samples for scientific analysis and development of identification tools for precious timbers

Cultivation of important timber species

LUKE V. ZAHNER

What do you think should the government do with its stockpiled rosewood, and why?

This is for the Malagasy government to determine in concert with international partners based on its obligations under CITES. One thing that is of concern to many, though, is the widespread belief that current stockpiles are being used to "launder" new wood. In other words, the old stockpiles are being switched out with newly logged wood, with the old logs being illegally smuggled out of the country. Thus the ongoing process of inventorying all of the stockpiles is a particularly critical step.

Can the illegal logging and traffic of precious wood in Madagascar be stopped, and how?

It takes everyone to come together to address this issue. As Deputy Assistant Secretary of State Shannon Smith told the press during her recent visit to Madagascar, it is both the supply and the demand sides of the equation that require action. On the demand side, receiving countries need to do more to interdict illegal wood coming into their countries and enforce the law against those smuggling it.

On the supply side, it takes a concerted effort at all levels. First and foremost, there must be clear political will to stomp it out once and for all. This includes prosecuting traffickers (no matter who they are or what their political or societal status is), and ensuring that rule of law is enforced throughout the country. Also, the independence of the judiciary must be protected, and insulated from external pressure. And environmental activists who speak out against these crimes should be protected, not prosecuted under stringent, though inconsistently applied, defamation laws that have a muzzling effect on civil society.

Lastly, the local communities have to participate too – recognizing that their livelihoods, and the livelihoods of future generations, are being jeopardized by deforestation and other illegal acts. As U.S. Ambassador Yamate said recently in Sambava (the epicenter of the illegal rosewood trade): "Floods become more extreme, storms worse, droughts more prolonged, as the forests disappear. This threatens everyone."

Please give in three key words, how you would improve this situation.

Community engagement | law enforcement | civic education

IMPRESSUM

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