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Ring-tailed Lemurs (*Lemur catta*), Forest Fragments, and Community-level Conservation in South-central Madagascar

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Abstract: The south-central highland region of Madagascar is largely deforested, except for rare, small forest fragments scattered across the landscape. Some of these fragments are now being managed by local community conservation associations, after village residents have seen, first hand, how decades of deforestation and, more recently, climate change in the region have affected their agricultural crops. Furthermore, ecotourism is becoming more common in this area, with the two largest fragments, Anja Community Reserve and the Tsaranoro Valley forest, frequently receiving both Malagasy and foreign visitors. The combination of revenue from such tourism and the prospects of greater food security (by conserving and expanding existing fragments, leading to better soil conditions for nearby crops and rice fields) has resulted in increased fragment preservation over the past few years. We surveyed seven of these fragments in August and September, 2013, with two goals: (1) to evaluate the viability of ring-tailed lemur populations in each fragment in relation to food and water resource availability; and (2) to discuss, with village conservation association leaders, the goals of each association regarding fragment conservation and benefits to local residents. Anja Reserve, operating since 1999, is highly successful, and the association's ecotourism and community development projects have won them national and international recognition. In 2012, village associations Sakaviro Miray, FI.MI.VA Samisorany, and Antokinihoavy-Andranobe received NGO funding to help build a tourism presence in the region, and infrastructure for such activities had begun when we visited these sites in 2013. The Tsaranoro Valley, where three of the fragments are located, is an adventure tourism destination; however, much of the tourism revenue goes to the owners of the trekking camps, although a portion of the funds are donated to the local Association Tantely each year, and these camps also provide jobs for local villagers. Recent efforts are underway to expand these three fragments via reforestation, and to create a corridor between two of them in order to assist with the dispersal of *L. catta* males, and thus assist with potential population gene flow.

Key Words: Community conservation, forest fragments, *Lemur catta*, south-central Madagascar

Introduction

In Madagascar, deforestation is considered exceptionally serious in the dry regions of the south (Bodin *et al.* 2006; Harper *et al.* 2007). Hannah *et al.* (2008) predicted that southern Madagascar will experience a mean temperature increase of 2.6°C in the 21st century, and that this largely arid region will become even drier, which will have important and largely negative biological consequences for its flora and fauna. Dry forest is the most fragmented forest type in Madagascar (Bodin *et al.* 2006; Harper *et al.* 2007), and in the south-central plateau (between Fianarantsoa and Andringitra National Park), continuous tracts of mixed deciduous, rupicolous, and dry-adapted forest—characteristic vegetation in this region—are no longer present (Google Earth 2015; Cameron and Gould 2013). A combination of slash-and-burn agriculture, tree-cutting for fuel, and conversion to agricultural land over several centuries has resulted in a landscape composed of grassland, occasional small and scattered forest fragments, agricultural crops, and villages (Cameron and Gould 2013). The ring-tailed lemur (*Lemur catta*) is the only primate present in such fragments (Cameron and Gould 2013; Gould and Gabriel 2015), and one goal of our project was to evaluate seven fragments containing populations of this species in the south-central region, in relation to (1) forest and matrix quality (available food and water resources for the lemurs) and (2) lemur population viability (Gould and Cowen in prep.). Additionally, we consulted with five community associations

that are currently working with regional, national, and international NGOs to improve both forest fragments and agricultural crop quality, with the aims of (1) providing sustainable, secure food sources for the human inhabitants of this region, and (2) developing and maintaining eco-tourism sites in forest fragments managed by the communities, which could result in much needed financial benefits to the people in the region. In this paper we describe the efforts made by these communities, and we identify variables that can lead to successful community forest conservation, benefitting both humans and wildlife.

Study sites

The sites are located in a 220-km² mountainous region of south-central Madagascar, between Sakaviro Community Reserve, the northernmost fragment (21°47'03.86"S, 46°52'02.11"E), Marody forest (southern limit at 22°05'34.25"S, 46°47'39.57"E), Tsaranoro forest at the western boundary (22°05'10.74"S, 46°46'24.59"E), and Andranobe Community Reserve to the east (21°57'47.04"S, 46°56'43.84"E; Figs. 1 and 2). The fragments fall into two sub-regions: four in the Ambalavao region and three located in the Tsaranoro Valley (Fig. 2). Fragment altitudes ranged from 982 to 1117 m above sea level. Forest fragments in this region are characterized by granite outcrops surrounded by a combination of semi-deciduous and southern, dry-adapted, rupicolous vegetation (Randrianandrasana 2011; Gould and Gabriel 2015). The areas between fragments are made up of grassland, villages, rice terraces, and garden crops and, in the case of Anja, a small lake used for pisciculture (Cameron and Gould 2013).

Small forest fragments are highly vulnerable to biodiversity loss (Fahrig 2003; Gibson *et al.* 2013), and mammalian biodiversity in the fragments in which we worked was low compared to larger, intact dry forests of the southern, southwestern, and south-central regions, for example, Beza Mahafaly Reserve (Sussman and Ratsirarson 2006; Sussman *et al.* 2012), Berenty Reserve (Jolly *et al.* 2006; Jolly 2012), and the western side of Andringitra National Park (Bloesch *et al.* 2002). *Lemur catta*, an extreme ecological generalist (Gould 2006), is the only primate found in these fragments. Local guides at each site stated that no nocturnal primates are found in these small forests, and our nocturnal survey of the largest fragment, Tsaranoro, revealed no sign of nocturnal lemur taxa. Larger predators such as fossa are absent, but we were told that a small carnivore locally known as "halaza" (likely the small Indian civet *Viverricula indica*) was present in most fragments, as are tenrecs (Family Tenrecidae).

Community-level Conservation Associations

We consulted with the following community-level associations: Anja Miray, Sakaviro Miray, FI.MA.VA Samisorany, Antokinihoavy-Andranobe, and Tantely. The first four are located in the Ambalavao region, and Association Tantely governs the villages and forest fragments of the Tsaranoro Valley (Fig. 2). Table 1 lists association names and years established, size (in hectares) of the fragments managed by each association, and approximate size of the *L. catta* populations in each fragment. We contacted the president of each association, and they and local guides accompanied us to the forests and assisted with the forest assessments and *L. catta* censuses.

We asked each association president the following questions: (1) what are the goals of the village association in terms of forest fragment conservation? (2) how will the community benefit from protection of the fragment? (3) are there plans for future fragment enhancement, for example, fragment expansion via reforestation, planting of potential vegetation corridors between fragments in close proximity, planting of trees in the matrix immediately surrounding the fragment that serve as food trees for *L. catta*? and (4) has the association received funding by an NGO to assist with the conservation program?

Association Anja-Miray (AMI) and the Anja Community Reserve

Established in 2000, the Anja Miray Association has been extremely successful in meeting its goals regarding forest conservation, and using monetary benefits from tourism

Figure 1. Map of Madagascar indicating region where the study was conducted.

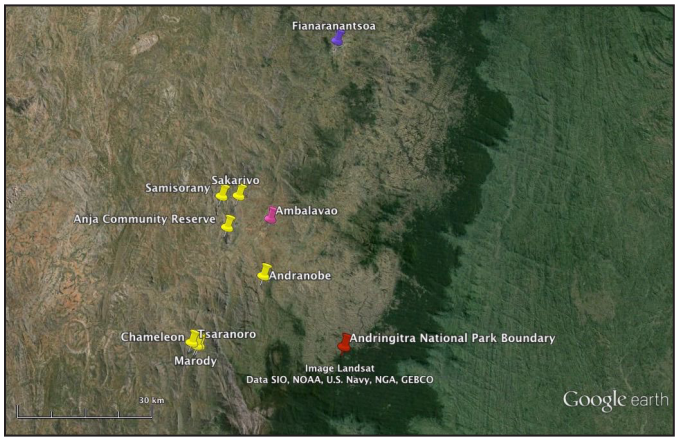

Figure 2. Location of each forest fragment visited during the study.

Table 1. Village associations and dates that each association was founded, fragment sizes, and population size of *Lemur catta* in each fragment as determined by census counts in 2013.

Village association (Communité de Base) and forest fragment name in English	Year association was established	Size of forest fragments managed by the associations (ha)	Approximate population size of *Lemur catta* found in each fragment in 2013 (adults and juveniles)
Ambalavao region			
Anja Miray (Anja Community Reserve)	2000	36	210
Sakaviro Miray (Sakaviro Community Reserve)	2012	14.2	30
Association FI.MI.VA Samisorany (Samisorany forest)	2008	20.3	21
Association Antokinihoavy- Andranobe (Andranobe-Andohabatonomby forest)	2012	Lower fragment=17.4 Upper fragment=20.7	Lower fragment=30 Upper fragment=6
Tsaranoro Valley region			
Association Tantely (Tsaranoro, Chameleon, and Marody forests)	2002	Tsaranoro=46 Chameleon=8 Marody=2.8	Tsaranoro=78 Chameleon=28 Marody=15

to help the community. The location of the Anja Community Reserve, just 13 km SW of the town of Ambalavao and immediately adjacent to Route Nationale #7 (21°51'09.44"S, 46°50'44.28"E), offers easy access to tourists, and Anja receives approximately 12,000 visitors each year, bringing in US$35,000−$45,000 annually (Rahaovilahy 2012). The main attraction is the large population of habituated ring-tailed lemurs (about 210−225 animals in 15 groups), and tourists can also view ancestral Betsileo tombs in the forest. Guides from the association lead tours and provide information on the history and cultural significance of the burial tombs, medicinal plants used by the Betsileo, and the behavior and ecology of the lemurs. AMI is composed of individuals from two villages who protect this 34-ha forest fragment for both community use and eco-tourism, the profits of which assist with community development and small-scale agriculture and pisciculture endeavors. In September 2013, AMI employed 85 guides and several trail managers. The association's successful conservation and development model has brought them regional, national and global recognition. In 2011, AMI won the national Communautés de Bases (COBA) prize as the best community association in Madagascar. The prize money was used for projects such as the construction of a school and distributing blankets to all elderly individuals in the region. In 2012, AMI was a recipient of the prestigious UNDP Equator Initiative Prize, awarded to just 25 development and conservation-based international projects every two years. AMI was selected as a finalist from over 800 entries worldwide. Also, in 2013, AMI was one of nine finalists competing for the NGO Argisud's regional agriculture prize.

Sakaviro-Miray, FI.MI.VA (Samisorany), and Antokinihoavy Andranobe

The 14.2-ha Sakaviro (21°47'03.86"S, 46°52'02.11"E), 20.3-ha Samisorany (21°47'11.35"S, 46°49'49.99"E), and 17.4-ha Andranobe (21°57'17.39'S, 46°55'36.44"E) forests are managed by the Communautés des bases (village associations) Sakaviro-Miray, FI.MI.VA, and Antokinihoavy Andranobe. The main objective of these associations is the conservation of the remaining forest fragments, in relation to both presence of water for successful agricultural yields, and to attract eco-tourists, who provide revenue for village projects. There is also a second fragment at Andranobe, at a higher altitude than the main forest, which contained few lemurs, was partially degraded, and was not included in the ecotourism plan. The association members are highly motivated to receive tourists after witnessing the success of Anja-Miray. In 2011 and 2012, all three associations received funding from NGOs Haona Soa, Global Environment Facility's Small Grants Program (GEF), and Ny Tanintsika. Haona Soa is based in Fianarantsoa, and finances small community projects related to the conservation of remaining forest and small-scale agriculture. The GEF program provides "financial and technical support to projects that conserve and restore the environment while enhancing people's well-being and livelihoods" (<https://sgp.undp.org>). Ny Tanintsika is a collaboration of international sponsors working with the Malagasy government with the objective of combating poverty through an integrative approach involving protection of nature coupled with sustainable development as well as health initiatives (<http://www.feedbackmadagascar.org/fr/aboutus>). The funding received from these NGOs has assisted the three community associations in establishing tree nurseries, constructing small tourist reception buildings, and erecting signs indicating the location of each site on major roads (Fig. 3). Furthermore, trails within the fragments have been established, and placards outlining the trail systems as well as regulations for tourists entering the forests have been posted at the entrances to the reception buildings. Tourists arrive at the reception office to pay the entrance and guide fees, and to meet with their guide, who then leads them on a tour of the forest. Although the ring-tailed lemurs in these forests are not as habituated to human presence as those at Anja, we noted that the two groups at Sakaviro, which had been operating for one year as of September 2013, were semi-habituated and tolerated the presence of tourists from approximately a 10-m distance (Fig. 4). Ring-tailed lemurs at Samisorany and Andranobe could be habituated if the associations are able to attract visitors interested in seeing their forests. In addition to lemurs, ancestral tombs decorated with zebu horns and remnants of historic dwelling walls are present at all sites, as well as artifacts preserved in rock shelters since at least the 19th

century (for example, potsherds, children's toys, cooking pots, fire rings, a prototype of the popular Fanarona board game at Sakaviro and, at Samisorany, a weaving loom). At all three sites, guides are eager to share stories of Betsileo ancestors, show visitors the artifacts that make up part of their cultural history, and find lemur groups for the tourists to view.

In 2003, there was a fire in the Samisorany area that destroyed a large tract of the forest in the region. In 2005, the villagers decided to protect the remaining forest and formed the Association FI.MI.VA Samisorany. Two species of *Ficus* (*F. megapoda* and *F. pyrifolia*) have since been planted in and at the edges of the fragment where maize was formerly grown.

Figure 3. Road sign indicating the location of the Sakaviro Community Reserve. NGO funding, which allowed for sign construction and tourism development, is acknowledged at the bottom of the sign.

Figure 4. *Lemur catta* juvenile at the Sakaviro Community Reserve.

In just a few years the forest has regenerated considerably, and few traces of the former crops can be found (Fig. 5).

Association Tantely and the Tsaranoro Valley forest fragments

The Tsaranoro Valley (22°05'10.83"E, 46°46'19.63"E), adjacent to the western border of the Andringitra National Park, contains three forest fragments that are managed by the Association Tantely: Tsaranoro, Chameleon, and Marody. The valley has become known over the past decade as a center for rock climbing and para-gliding, and has recently been included in Madagascar travel guidebooks. Ecotourism in the largest fragment, the Tsaranoro forest (46 ha), is growing—tourists wishing to see ring-tailed lemurs (six groups totaling approximately 78 individuals), ancestral Betsileo tombs, caves, and a natural springs pool are accompanied by guides working for the trekking camps, and sometimes local guides. Association Tantely is composed of 11 villages. Toll fees are collected along the road leading to the Tsaranoro Valley, and this money is used for funding the Association's projects, such as trail maintenance inside the Tsaranoro forest, construction of fire breaks around Tsaranoro and the nearby Chameleon and Marody fragments, and road maintenance. The smaller Chameleon and Marody fragments (8.4 ha and 2.8 ha) could be used for ecotourism/lemur watching, as both contain small populations of *L. catta*, and Marody is situated very close to an exit trail from Andringitra National Park. Ecotourists trekking through Andringitra pass Marody on their way to the ecotourist camps and, since *L. catta* are difficult to locate in the vast and mountainous Andringitra Park area (31,160 km²), visitors hiking from Andringitra to Tsaranoro could potentially visit Marody to see the group of lemurs living in this small forest. Local villagers working with the guides from the Association Dyal (a guide association based in Ambalavao) are eager to conserve and further develop these fragments for tourism purposes.

In 2013, four ecotourism camps were operating in the Tsaranoro valley, catering primarily to foreign climbers and hikers. The owners of the camps—three French expatriates and one Malagasy (the second author P.A.)—donate part of their profits to Association Tantely. Projects funded by the camps thus far include construction of a church, school,

Figure 5. View of the 19-ha Samisorany forest fragment. The forest has regenerated well following a major fire in 2005.

medical clinic and village wells. Local villagers are employed in the camps in a variety of jobs, although the actual trekking/climbing guides working at the camps are not from the valley.

Potential for community conservation success in south-central Madagascar

The associations with whom we worked were motivated to build an ecotourism presence in the south-central plateau region, particularly after witnessing the immense success of Anja Reserve. Anja has the advantage of an established 15-year tourism profile, and is visible from Route Nationale #7, just south of the town of Ambalavao. The smaller forests of Sakaviro and Samisorany are located further from the main highway, but if the community groups are able to promote their small forests via, for example, leaflets posted in the Ambalavao hotels, and being included in field guides and on travel websites, they could be successful, although to a lesser degree than Anja. The Andranobe Andohabatonomby reserve is found along a secondary road leading to Andringitra National Park, and could attract tourists headed for the national park if they engaged in some form of advertising.

Guides at Anja speak a number of languages, which is very helpful in terms of leading tours made up of foreign visitors. At Sakaviro, Samisorany, and Antokinihoavy-Andranobe, the guides speak only Malagasy, and this could pose a problem in terms of both promoting the forests and guiding foreign visitors, thus instruction in basic French, English, and German phrases (the three primary languages spoken by tourists to Madagascar) would be an asset. The Tsaranoro forest already receives quite a number of adventure tourists during the dry season, and the nearby Chameleon and Marody forests could easily become part of the forest tour, which currently includes only the larger Tsaranoro fragment. The guides working at the trekking camps do speak French and some English, but villagers interested in becoming involved with the ecotourism presence in the Tsaranoro valley would benefit greatly from learning basic phrases in both languages, so that they too could interact with tourists and benefit from tourism dollars.

Figure 6. *Lemur catta* climb along large boulders at the Anja Reserve.

Another important incentive for these communities to conserve and expand the forest fragments relates to increasing desiccation of arable land, caused by continuous deforestation and grass fires. Community presidents talked about the effects of local deforestation and resulting climate change. For example, in one community, previous rice yields were approximately 30 sacks per year, but in 2012, only eight sacks were harvested. Furthermore, locust plagues are more frequent in this region in the past few years, and crops have sustained serious damage from these insects. The loss of agricultural revenue has made local communities aware that without any forests, the very notion of food security will disappear, and this realization has sparked recent interest in the conservation and expansion of these small fragments.

Unfortunately, not all communities in the south-central region are motivated to conserve remaining small tracts of forests. We visited two other fragments, Bedita, near the Tsaranoro Valley (6 ha), and Ikomby (2 ha), three kilometers from Sakaviro Community Reserve, both containing very small *L. catta* populations. Both forests were severely degraded. At Bedita, villagers cut trees inside the fragment for firewood, and we found numerous remnants of recent fires set within the forest itself. At Ikomby, local people cut trees and collect considerable amounts of firewood at least once per week. We were told that while some of the local villagers near the Ikomby fragment want to conserve the small remaining forested area, others wish to continue harvesting the wood. These fragments are completely surrounded by anthropogenically-produced grassland, and the President of Association FI.MI. VA Samisorany mentioned that just 15 years prior to our visit, tracts of continuous forest were still present in this area.

The future of community managed forest fragment conservation in south-central Madagascar

The first author of this paper (LG) received a small grant from Conservation International's Primate Action Fund in 2013, and a portion of the funds were donated to the community associations of Sakaviro, Samisorany, Antokinihoavy-Andranobe, and Tsaranoro (Association Tantely) in August and September 2013 to (1) establish tree nurseries, the saplings of which will be planted at fragment edges to expand the small forests and provide more food trees for the resident ring-tailed lemur populations; (2) construct trail signs within each fragment; (3) clean and maintain the trails, making access easier for visitors; and (4) construct fire-breaks around some of the fragments, as grassfires set outside of the forests to encourage new grass growth for cattle often burn out of control in this region. As of October, 2013, the following actions had taken place. At Sakaviro Community Reserve, Samisorany and Tsaranoro, association members had begun to establish new tree nurseries to be planted for fragment expansion. In September 2014, a colleague of first author LG visited the Sakaviro Community reserve, and sent a photo of a thriving tree nursery, partially funded by the money that we provided to the Sakaviro Miray Association. The saplings grown in this nursery will be planted at the perimeters of the

reserve (P. J. Perry pers. comm). In June, 2015, second author (PA) noted that while some trees had been planted between the Tsaranoro and Chameleon fragments, rice growers in the valley did not want trees infringing on the rice terraces situated between the two forests, so it is unclear whether planting a connecting corridor will be possible.

In the Tsaranoro Valley forest, removal of the parasitic *Cissus quadrangularis* vine, Veldt grape, which had encroached upon the eastern part of the forest, had commenced, and a tree nursery was in the planning stages—the resulting saplings will be planted between the eastern edge of Tsaranoro and the southwestern edge of the Chameleon fragment. The distance between these two fragments is just 0.8 km, and such expansion could facilitate *L. catta* male dispersal between fragments. This is especially important, because while Clarke *et al.*'s (2015) examination of *L. catta* population genetics at Anja, Tsaranoro and Sakaviro revealed moderate levels of genetic diversity, the authors caution that these populations may be exhibiting a time-lag response before significant loss of genetic diversity occurs in the near future, due to extreme population fragmentation and the inability, in most cases, for male *L. catta* to disperse. In the small Marody forest, a sign indicating the trails within the fragment had been posted.

The management and development of ecotourism activities in some of the remaining forest fragments in this region has engendered local pride regarding endemic flora and fauna, and fostered an awareness of the importance of forest conservation. The establishment of these community conservation projects has brought extra income, and in some cases, national and international recognition for these local associations. We hope that the initiatives and projects described in this paper will continue and thrive so that the local communities, the remaining forest fragments, and the ring-tailed lemur population living within the fragments in this region of Madagascar will benefit in years to come.

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