Primate Conservation 2020 (34): 61-70

Lemur Distribution and Resident Attitudes Towards Forest Loss and Degradation in Ankarafantsika National Park, Madagascar

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Abstract: Lemurs across Madagascar are threatened with extinction. This threat is largely associated with lemur habitat being converted for agriculture resulting in increased fragmentation of their forest. It is important, therefore, to record species presence across their geographic range in order to observe any local extinctions and at-risk populations, to provide accurate information on population size, and identify species that are most at risk of extinction in the wild. Ankarafantsika National Park is one of the last deciduous dry forests in Madagascar under state protection. Eight lemur species are known to occur in and around the park: *Avahi occidentalis*, *Eulemur fulvus*, *Eulemur mongoz*, *Lepilemur edwardsi*, *Microcebus murinus*, *Microcebus ravelobensis*, *Cheirogaleus medius*, and *Propithecus coquereli*. Pressures on the forest of Ankarafantsika, such as logging and fire, have reduced forest cover and increased fragmentation. We conducted a rapid assessment of the occurrence of lemurs and their relative abundance around the periphery of the park, including sites that had not been surveyed previously. We also aimed to determine how the local communities perceived forest loss and the presence of these lemurs. We completed 10 diurnal and 19 nocturnal lemur surveys at nine sites and interviewed 11 residents in four villages close to the park boundary. We found seven of the eight species present within Ankarafantsika, and site- and species-level differences in encounter rates. Species richness differed across sites and may be negatively related to levels of anthropogenic disturbance at these sites. We found differences in the respondents' knowledge of the forest according to their sex, and residents reported declining numbers of lemurs, and increased fires and charcoal production that has negatively impacted the forest during their lifetimes. We highlight the need for long-term monitoring of lemur populations across the park and immediate conservation action to protect forests and lemurs.

Key words: Biogeography, lemur communities, conservation, deforestation, species richness, rapid assessment

Introduction

The lemurs of Madagascar and the Comoros are the most endangered animal group in the world (Schwitzer *et al.* 2013); the most recent IUCN Red List assessment (July 2020) lists 105 (94.6%) of the 111 species and subspecies as threatened (IUCN 2020). These primates are primarily arboreal, and many species have very restricted distributions (Goodman and Benstead 2005; Schwitzer *et al*. 2013). Even within the species' ranges, their populations are patchily distributed (Wright *et al.* 2008). Approximately 44% of forests in Madagascar have been converted to non-forest since the 1950s (Vieilledent *et al.* 2018) and, given this forest loss and fragmentation across Madagascar, it is imperative that we monitor the occurrence and abundance of the different species of lemur over time and across different spatial scales to gain a better understanding of the threats and their impacts.

The effects of habitat loss and degradation on lemurs are well studied (Schwitzer *et al.* 2013; Schüßler *et al.* 2018; Kling *et al.* 2020). Habitat loss is the greatest threat (Schwitzer *et al.* 2013) but the impact of habitat degradation is more complex. Some lemurs have shown positive responses to habitat degradation. *Avahi laniger* and *Microcebus* cf. *simmonsi,* for example, have been found at higher densities in regenerating secondary forest compared to mature forest (Miller *et al*. 2018). Bamboo lemurs (*Hapalemur meridionalis*) use

habitats dominated by invasive plants, which allow them to tolerate habitat degradation and fragmentation (Eppley *et al.* 2015). Schüßler *et al.* (2018), however, reported that lemur species diversity was negatively impacted by habitat degradation.

Ankarafantsika National Park in northwest Madagascar is primarily deciduous dry forest. It hosts eight species of lemurs (Alonso *et al.* 2002; Razafy Fara 2003; Mittermeier *et al.* 2010; Gautier *et al.* 2018). Research and associated conservation efforts in the park have been primarily centred around Ampijoroa, an area located close to the Madagascar National Parks (MNP) headquarters along the national road RN4 (e.g., Thorén *et al.* 2010; Joly 2011; Ramsay *et al.* 2017). Information on the degree of disturbance to the forest, and the effect of this disturbance on lemur species in other areas of the park is, therefore, limited. Ankarafantsika has been highlighted as a priority area for lemur conservation by the IUCN Species Survival Commission (Schwitzer *et al.* 2013). The IUCN SSC action plan for lemur conservation (Schwitzer *et al.* 2013) recommends increased rapid assessment surveys of remote locations within the park (Radespiel and Razafindramanana 2013). Despite its status as a national park, activities such as logging, deforestation, and hunting threaten the lemur populations there (García and Goodman 2003; Guschanski *et al.* 2007; Radespiel and Raveloson, 2001), and while fires are typical components of the seasonal cycle of deciduous dry forests, increased instances of uncontrolled fires may have detrimental effects on the flora and fauna and their ability to recover from severe damage (Gautier *et al.* 2018).

Studies of lemurs in Ankarafantsika but outside of Ampijoroa have revealed that some species are widespread, mouse lemurs, for example (Guschanski *et al.* 2007; Radespiel *et al.* 2008; Rakotondravony and Radespiel 2009; Steffens and Lehman 2018, 2019), whereas others may have been locally extirpated, the woolly lemur *Avahi occidentalis*, for example (Steffens and Lehman 2019). Species richness and occurrence in some areas of Ankarafantsika have been shown to be positively related to the habitat available, especially for species larger than *Microcebus* (Steffens and Lehman 2018, 2019). *Propithecus coquereli* numbers drop near forest edge and roads (Kun-Rodrigues *et al.* 2014). In 1997, Schmid and Rasoloarison (2002) carried out a rapid assessment at three sites in the interior of the park that revealed the presence of eight lemurs—five nocturnal, two cathemeral, and one diurnal. Besides providing valuable information on lemur diversity in the three locations, it revealed lower levels of disturbance in the east of the park, furthest from the national road (Schmid and Rasoloarison 2002).

Community-based conservation initiatives aim for a bottom-up approach to managing landscapes in contrast to the top-down approach of so-called "fortress conservation" (Adams and Hulme 2001). When Ankarafantsika was first established as a protected area in 1927, it was classed as a "Réserve Naturelle Intégrale" (Virah-Sawmy *et al.* 2014). As a result of the declared "Durban Vision", announced at the Vth World Parks Congress in Durban in 2003, it was elevated to a national park, and there was, besides, consideration given to including residents of the local communities into management decisions, management activities, and as benefactors of management (Aymoz 2013). For example, there is a buffer zone on the edge of the park that is managed by local communities, and 50% of the fee charged to visit the park is dedicated to conservation/development projects aimed to benefit local people (Aymoz *et al.* 2013). The implementation of community-based conservation projects has, however, suffered some set-backs. A commercial-based community forest management program near Ankarafantsika, for example, was unsuccessful in protecting the forest (Rasolofoson *et al*. 2015). In the Ambohitantely Special Reserve in the central highlands, Klein *et al.* (2007) found that the implementation of community-based conservation strategies actually followed a top-down approach, as they neglected to understand the needs and interests of local communities; a situation that resulted in raised tensions towards conservation activities. They found that, although poverty was considered the greatest threat to forest conservation, most damage to the forest was caused by fires set by relatively wealthy people, who own and graze cattle near the protected area. Thus, it is important to understand local dynamics, perceptions, and attitudes related to conservation and management of protected areas in Madagascar (Kaplin 2005). In Ankarafantsika, local residents around the periphery of the park have the least positive perspectives on conservation actions, compared to those in the interior (near Ampijoroa) or where the Madagascar National Parks agents are employed (Aymoz *et al*. 2013). These areas could, therefore, benefit from integration of these communities into conservation initiatives, taking into account community perspectives on effective ways to protect the habitat and the lemur species present (Fritz-Vietta *et al*. 2011).

We walked the perimeter of Ankarafantsika National Park, to (i) assess the distribution of lemur species across the park and (ii) discuss changes to the forest that residents had observed over their lifetimes, as well as their current attitudes towards conservation. We used a rapid assessment survey technique to obtain information on lemur species occurrence and relative abundance around the national park, and interviewed people who have lived within or near to the park over the last few decades to see their perspective on changes to the forest and lemur species. Dialogue with older residents allowed us to gain qualitative information on rates of changes and how these are viewed. These perspectives can help us to identify priority areas for species monitoring and the communities that are interested in future conservation initiatives.

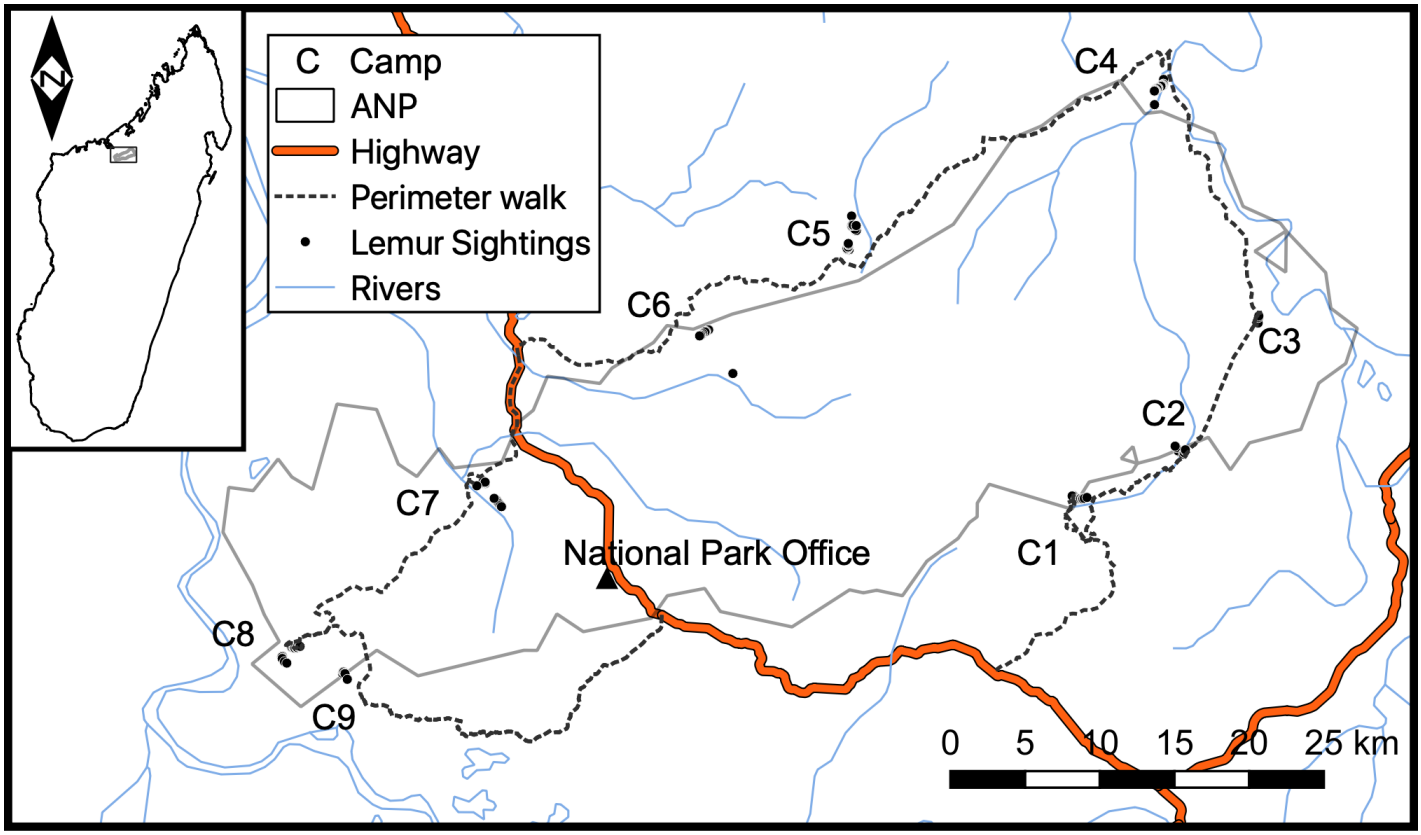

Figure 1. Map of rapid assessment path, camp, and sighting locations in Ankarafantsika National Park (ANP), Madagascar. C# = locations for each camp near survey transects.

Methods

Study area

Ankarafantsika National Park (135,800 ha) is located at 16°6'55.29"S, 47°05'49.10"E on the Route National 4 (RN4), approximately 115 km southeast of Mahajunga in the Boeny region, northwest Madagascar. The park has eight known lemur species (Table 1) and comprises a mosaic of dry deciduous forest and secondary grassland created by anthropogenic activities (Gautier *et al.* 2018; Radespiel and Razafindramanana 2013). There are approximately 60 communities within and near the park boundaries, with an estimated total population of 100,000 (Madagascar National Parks 2017). We conducted this survey over a period of 14 days from 28 June – 11 July 2019. We walked the perimeter of the park (Fig. 1) to gain access to areas distant from Ampijoroa and the national highway (RN4).

Lemur surveys

We selected nine villages around the periphery of the park as bases, near to which we could set up temporary camps (Fig. 1), to facilitate access to trails, local assistants, and water. We conducted lemur surveys in forest near to each of the nine camps around the park using the line-transect method on existing trails. These trails were all in the continuous forest inside the park boundary with the exception of Camp 5 where we surveyed a large fragment on the edge of the park boundary (Fig. 1). We conducted a total of n = 29 (10 diurnal; 19

Table 1. Characteristics of eight lemur species found in Ankarafantsika National Park.

Species	Body mass (g)*	Activity pattern	Diet	IUCN Red List status**
Cheirogaleus medius	120–270	Nocturnal	Frugivore	Vulnerable
Microcebus murinus	58– 67	Nocturnal	Omnivore	Least Concern
Microcebus ravelobensis	56–87	Nocturnal	Omnivore	Vulnerable
Propithecus coquereli	3700–4300	Diurnal	Folivore	Critically Endangered
Eulemur fulvus	1700–2100	Cathemeral	Frugivore	Vulnerable
Eulemur mongoz	1100–1600	Cathemeral	Frugivore	Critically Endangered
Lepilemur edwardsi	1100	Nocturnal	Folivore	Endangered
Avahi occidentalis	800–1100	Nocturnal	Folivore	Vulnerable

*From Mittermeier *et al.* (2010)
**Version 2020-2 (IUCN, 2020).

nocturnal) surveys over 14 days and nights surveying a total distance of 22.15 km. Each survey team consisted of 2–4 individuals.

We collected the following data at the beginning and end of each transect; Survey number, date, surveyors' names, start time, GPS coordinates at the start of the trail, heading of trail, temperature, cloud cover, moon phase if applicable, end time, GPS at end of trail, distance walked, total number of sightings, number of species. We walked each transect at a speed of 0.75 and 1 km/hr for nocturnal and diurnal surveys, respectively. When an animal was seen (visual sighting) or heard (auditory sighting), we recorded the following: date, time, side of transect, species, distance along transect (m), observer GPS, trail heading, lemur heading, distance to the center of the group, perpendicular distance along transect, perpendicular GPS, perpendicular distance to centre of the group, group spread, height of the animal, number of individuals, behaviour, and method of detection (visual or auditory). A visual or auditory record was considered one sighting regardless of the number of individuals observed (i.e. groups were treated as a single sighting).

We calculated the relative abundance of each species (by camp and by species overall) as the encounter rate (number of sightings of each species per km walked). We define species richness as the total number of species observed near each camp. Unfortunately, we could not discriminate between the two, mouse lemur species, found in the park, *M. ravelobensis* and *M. murinus*. Although there are differences in occurrence and abundance for each species at small scales, both species were considered to occur throughout the park (Jolly *et al*. 2011; Andriaholinirina *et al.* 2020). We, therefore, considered occurrence of *Microcebus* spp. to represent both.

Qualitative assessments of forest disturbance and resource use

In addition to walking survey transects, at three communities (Andranomidtra, Beronono, and Sainte Marie), we conducted reconnaissance walks across larger areas (2–10 km). On transects and these reconnaissance walks we observed the integrity of the forest, signs of resource use, and wildlife in the area. We did not systematically quantify the amount of disturbance we observed but qualitatively noted the main anthropogenic activities near each camp such as: existence and type of trails, existence and the relative amount of the following: charcoal production, fire disturbance, extraction of tubers (*Dioscorea maciba*), traps for hunting, and cut trees. Based on the above qualitative assessment, we ranked each camp as having a high or low level of disturbance, and if high indicated what was the driver (for example, fire, charcoal production, or both). To achieve a high ranking the forest around the camp had to have extensive forest loss or disturbance, while a low ranking had little forest loss or disturbance. We then compared the qualitative level of anthropogenic disturbance to lemur species richness observed at each camp.

Interviews with local residents

We conducted interviews in four communities (see Supplementary material for Interview questions and replies, Table S1: Andranomidtra, Beronono, Sainte Marie, and Ampombolira) using an open-ended questionnaire. In each community we asked the community leader to facilitate interviews with volunteers among elder members of each community. Prior to being interviewed, we read an ethics statement to each participant about the use of the information being collected and asked whether they consented to being interviewed. Interviews typically lasted 20–30 minutes and were recorded using an Olympus Vn-8100PC digital voice recorder.

Results

We completed our walk around the park by primarily following a firebreak/vehicle track around the perimeter. We covered 220 km. We completed a total of 29 lemur surveys and three opportunistic walks (Table 2). We interviewed 11 members of the four communities (Andranomidtra, Beronono, Sainte Marie, and Ampombolira) including seven men and four women (Table S1).

Lemur surveys

We recorded the presence of the following lemurs in the Ankarafantsika National Park: *Microcebus* spp. (probably two species), *Lepilemur edwardsi*, *Avahi occidentalis*, *Eulemur fulvus*, *Eulemur mongoz*, and *Propithecus coquereli* (Fig. 1). We did not observe *Cheirogaleus medius*, which hibernates during the dry season (Dausmann *et al*. 2005). Species richness was highest at camps 4 (Beronono; n = 7) and 7 (Ambarindahy; n = 6; Table 3). Relative abundance was highest for *Microcebus* and lowest for *Eulemur mongoz*. Our one sighting of *E. mongoz* was opportunistic, during a reconnaissance walk and not on a survey (Table 4). The relative abundance of all species by camp ranged from 0.0–3.28 individuals/km for diurnal walks and 6.27–22.00 individuals/km for nocturnal walks.

Interviews

Community member responses about their daily tasks differed by sex. The women reported that their daily tasks typically included cooking meals and monitoring rice fields; they didn't know about wildlife because they rarely went into the forest. The men reported that their daily tasks included monitoring rice fields and occasionally going into the forest. Six of the 11 men interviewed said that they had perceived a decline in the wildlife over time (Table S1).

There were some regional differences in the nature of deforestation reported by respondents around Ankarafantsika. At Camp 1 (Andranomidtra), three of four respondents reported that deforestation was caused by immigrants from the "south," who cut the trees to produce charcoal (Table S1). Respondents at Camp 4 (Beronono) reported that the

Table 2. Overview of the survey sites. Data include, the number of transects at each camp (#T), the total number of surveys completed (diurnal (d)/nocturnal (n)), total distance surveyed (TDS), species richness (SR), relative human disturbance regime (HDR). **Microcebus* spp. – two species.

Camp		#T	# Surveys (d/n)	TDS (m)	SR*	HDR
C1	Andranomidtra	2	5 (2/3)	3,307	4	High; Charcoal
C2	Bevazah	2	4 (2/2)	2,594	4	High; Combination
C3	Ambahimalandy	1	1 (0/1)	775	2	High; Combination
C4	Beronono	1	3 (1/2)	3,000	7	Low
C5	Sainte Marie	2	6 (2/4)	4,566	4	High; Fire
C6	Mahatanzana	2	3 (1/2)	2,565	2	High; Fire
C7	Ambarindahy	2	4 (2/2)	2,959	6	Low
C8	Ampombolira	2	2 (0/2)	1,774	2	High; Combination
C9	Bealana	1	1 (0/1)	606	4	Charcoal
Total		15	29 (10/19)	22,146	7	

Table 3. Encounter rate (sightings per km) by species. * Only nocturnal surveys.

Species	Total visual sightings/km	Total auditory sightings/km	Combined visual/auditory sightings/km	All sightings/km combined (including opportunistic)
Microcebus spp.	9.92*	N/A	9.92*	4.40
Lepilemur edwardsi	0.42*	0.42	0.83*	0.37
Avahi occidentalis	0.21*	0.07	0.28*	0.12
Eulemur fulvus	0.14	0.27	0.41	0.28
Eulemur mongoz	0	0	0	0.03
Propithecus coquereli	0.05	0	0.05	0.12

park limits were moved from nearby the village to farther away, and the community members used the forest between the village and the new park limit for their daily needs (Table S1). At Camp 5 (Saint Marie) a respondent suggested that fire was the main factor reducing the size and quality of the forest around the community (Table S1). Both respondents at Camp 8 (Ampombolira) also suggested fire generated from outside the community was the main cause of forest loss near the community.

The majority of respondents found value in the forest but said that the forests near their communities had diminished in recent years (Table S1). Most respondents claimed that forest is either farther from their community (8/11) or degraded (3/11). They reported a reduction in forest from increased fires, local residents clearing land, and immigrants clearing forest for charcoal. Two respondents noted that the remaining forest is now warmer than when there was more forest. Eight of the respondents commented that there is less wildlife including lemurs following the reduction in forest near their community. Most respondents felt that the forest is useful. Respondents reported that the forest provided trees for human use (10/11), for example for building and firewood; water (7/11) and clean air (3/11); medicinal plants (2/11); homes for wildlife (2/11), and shade (1/11). Nine of the eleven respondents felt that the loss of forest has affected their community negatively. One felt that there was a positive benefit from forest loss (firewood was easier to collect), and another claimed there was no impact. Three respondents reported that their community did not participate in conservation activities, while seven reported that their communities had helped create and maintain firebreaks, and one told us that their community had planted trees. Only one respondent (C5 Sainte Marie) knew of external organizations helping to conserve forest. Nine respondents commented that Madagascar National Parks engaged in conservation activities, and six reported that local communities did the same (Table S1). Nine respondents wanted forest restoration activities near their communities, one respondent did not want change, and another did not respond to this question.

Forest disturbance and resource use

Although we did not collect systematic data on forest disturbance or resource use over the course of the expedition, we made note of anthropogenic activities. We observed that C1 (Andranomidtra) was characterized by extensive forest loss and we saw evidence of charcoal production. There were large and clear existing trails and evidence of the forest being used by zebu cattle (*Bos taurus indicus*) near to these transects.

Table 4. Mean Encounter Rate (sightings/km) by camp and survey type.

Camp	Name	Survey type	Average visual sightings/km	Average auditory sightings/km	All sightings/km combined (incl. opportunistic)
C1	Andranomidtra	Combined	6.32	1.78	8.10
		Diurnal	0.00	0.00	0.00
		Nocturnal	10.53	2.97	13.50
C2	Bevazah	Combined	4.99	1.16	6.16
		Diurnal	0.00	0.00	0.00
		Nocturnal	9.98	2.33	12.31
C3	Ambahimalandy	Nocturnal	5.16	1.29	6.45
C4	Beronono	Combined	9.75	1.29	0.00
		Diurnal	0.50	1.75	1.71
		Nocturnal	19.00	0.50	22.00
C5	Sainte Marie	Combined	9.61	3.00	11.81
		Diurnal	0.00	2.20	0.00
		Nocturnal	14.41	0.00	17.72
C6	Mahatanzana	Combined	3.59	3.31	4.18
		Diurnal	0.00	0.59	0.00
		Nocturnal	5.38	0.00	6.27
C7	Amborandahy	Combined	6.12	0.88	8.60
		Diurnal	1.84	2.48	3.28
		Nocturnal	10.40	1.45	13.92
C8	Ampombolira	Nocturnal	10.38	3.52	11.88
C9	Bealana	Nocturnal	11.55	1.50	16.05
Total diurnal			0.43	0.35	0.91
Total nocturnal			11.38	2.68	14.06
Total			7.36	1.82	9.24

At C2 (Bevazaha) we observed low levels of forest disturbance, and only little evidence of charcoal production. At C3 (Ambahimalandy) we encountered one trap set for bush-pigs (*Potamochoerus larvatus*). C4 (Beronono) is a large village along the banks of the Mahajamba River. The forest itself was relatively intact with little evidence of logging or charcoal production. However, we did observe evidence of collection of maciba (*Dioscorea maciba*; small tubers similar to manioc) and one area that had been affected by fire. C5 (Sainte Marie) was situated in a fragment on the edge of the park. The fragment contained a small hamlet and the park base station. Compared to the other camps, C5 appeared to have more evidence of maciba extraction, fire, and trails. C6 (Mahatazana) was characterized by heavy fire damage which penetrated into the forest. C7 (Ambarindahy) was situated in a river valley and had moderate levels of disturbance including trails, cut trees, evidence of maciba extraction, and fire. C8 (Ampombolira) was characterized as having numerous trails, evidence of fire, and some cut trees. At C9 (Bealana) we camped at the Madagascar National Parks' base station and the forest was approximately 1.5 km away. Here the forests have been cleared and there was substantial charcoal production. In summary, C1 and C9 shared similar charcoal production issues, C2, C3, and C8 had moderate levels of impact from various sources. C4 and C7 were the least disturbed and C5 and C6 were the most impacted by fire.

Lemur species richness and forest disturbance

We found seven species near C4 and six near C7—both communities have relatively low levels of anthropogenic disturbance. In the areas with relatively high levels of charcoal production such as C1 and C9, areas that see more frequent and large fires such as C5 and C6, or had a combination of anthropogenic disturbance (C2, C3, and C8) fewer species were present (2–4 species).

Discussion

Through our rapid assessment we assessed the occurrence and relative abundance of lemurs along the periphery of Ankarafantsika National Park. We assessed areas near to the forest edge which are accessible to the communities and are exposed to daily anthropogenic activities. Although many studies have assessed the occurrence of lemurs in the park (Radespiel and Raveloson 2001; Schmid and Rasoloarison 2002; Steffens and Lehman 2019), to date, no studies have looked at species richness across the entire perimeter of the park. During this study we observed seven of the eight species that have previously been recorded in Ankarafantsika (we did not see *C. medius*). There were, however, differences in the occurrence rate and relative abundance of lemurs between survey locations. Observed differences in species richness and relative abundance among survey sites may be because of variation in disturbance regimes and their intensity. Lemur species richness was not uniform around the perimeter of the park. We qualitatively assessed species richness in relation to disturbance and found that it was lower in areas with higher anthropogenic disturbance. Although our sample sizes are small, our results suggest that human disturbance such as charcoal production, and large frequent fires impacts lemur species richness.

There are differences in species richness and relative abundance between our study and other studies. C4 (Beronono) was the only survey site where we observed all seven species at one location. This differs from Schmid and Rasoloarison (2002) who recorded seven species (including *C. medius*) at Ankarokaroka and six species each at Antsikoky and Tsimaloto (sites located in the forest interior). While Tsimaloto is in the same area as our survey site C2 at Bevazah, it is approximately 3 km farther into the interior than our survey transects where we only observed four species (*Microcebus* spp., *E. fulvus* and *L. edwardsi*). Near C2 (Bevazaha) and C5 (Sainte Marie) we recorded four species of lemur in each site, whereas Radespiel and Raveloson (2001) recorded four near Bevazaha and six near Sainte Marie. Two of our survey sites (C4 and C9) were previously surveyed by Kun-Rodrigues *et al.* (2014), during their survey of *P. coquereli* at four sites across the park. Both studies found *P. coquereli* at each site. We, however, observed only one group of *P. coquereli* opportunistically at C4 (Beronono) and one group during a nocturnal survey at C9 (Bealana). With greater survey effort Kun-Rodrigues *et al.* (2014) reported finding 42 groups at Beronono and 23 groups at Bealana. However, it is difficult to compare the abundance of lemurs between studies and study sites due to multiple factors that are not consistent among studies, such as survey effort and methods. We did not have the same level of survey effort in each site as other studies had as our main aim was to survey the perimeter of the entire park rather than carry out intensive local surveys.

Reports from local residents highlight that increased forest loss and disturbance is occurring within and near the park. The interviewees also made connections between a lack of forest and a reduction in wildlife near their communities. Reasons why forest was removed near their communities differed across the park, however. At C1, for example, residents reported that forest loss along the southern end of the park is the result of "southern" Tandroy immigrants removing trees for charcoal production. The Tandroy are a nomadic ethnic group originally from the Androy region of southern Madagascar, who rely less on water-based agriculture and more on other crops such as maize and raising zebu cattle (Waeber *et al*. 2015). They collectively pioneer new land to extract charcoal then divide the transformed land into smaller parcels to be used by the Tandroy immigrants to grow maize to buy zebu (Muttenzer 2012; Waeber *et al.* 2015). Waeber *et al*. (2015) suggest that the land use practices of Tandroy explains the decrease in forest cover in Androy and now the southern side of the park. We noticed evidence of charcoal production, including trees felled and stacked ready to burn, bags of charcoal, and previously used charcoal firepits, just outside the park at C1 and within the park boundaries at C9, including areas where we saw lemurs. At C8 and C9, residents report that fire is the main cause of forest loss around their communities. Fire is a natural process typical to dry forest environments but is also used by local cattle owners to promote new grasses for their cattle to graze (Bloesch *et al.* 1999; Gautier *et al.* 2018). However, there has been an increase in fires, coupled with the increased use of burning land for cattle, that has resulted in less forest and more secondary grassland within and along the periphery of the park (Gautier *et al.* 2018). Steffens and Lehman (2018, 2019) reported that repeated use of fire and cattle grazing has created a fragmented landscape that has negatively impacted lemur species richness and occurrence. Finally, residents in C4 reported that deforestation near their community was conducted by community members to plant rice fields to grow food for the community. Converting forest for agriculture is common practice in Madagascar (Harper *et al.* 2007). The practice of cutting down forest has been integral to many communities to grow food (Scales 2014). Although this has complex effects on the environment (Scales 2014), some of the unintended consequences of removing forest result in decreased biodiversity (Schwitzer *et al.* 2013), increased erosion, and localized changes in rain and water tables (Zwartendijk *et al.* 2017).

Our rapid assessment of lemurs and interviews of local residents around Ankarafantsika suggest that the forest and lemurs in and around park continue to be under threat. The main threats include charcoal production and large fires. We found few lemur species per site and had lower encounter rates for all species within the park relative to previous rapid assessments, with the exception of *Microcebus*, which are relatively abundant and ubiquitous. We cannot speak for *C. medius*, which was hibernating during our study. Anthropogenic disturbance varies across the park. We suggest that urgent action is needed to alleviate the impact of charcoal production in the south and fires in the north.

Providing solutions for cattle owners may include local and federal strategies that allow for controlled fires to be

set (Klein *et al.* 2007) that allow for this income-generating activity while minimizing the impacts on the ground. Similar to Ambohitantely Special Reserve, fire is not tolerated in some parts of the park, and cattle owners there have no incentive to stop runaway wildfires from burning the forest. Strategies that allow cattle owners to use fires in a way that is also beneficial to future forest growth (i.e. reduce fuel load to prevent even larger fires) could be used in areas where fire poses a greater risk to forest. Patrols and physical fire-breaks have been found to provide some level of protection to forest within the park (T. S. Steffens unpubl. data). The few sightings of larger species, including the Critically Endangered *P. coquereli* and *E. mongoz*, warrants continued investigation to determine the parkwide distribution and population structure for these species. Species-specific action plans should be drawn up for these species in order to reverse what appears to be a declining trend in their geographic range and population size.

Our study is limited by two main factors. The first, is the wide area covered and the limited time of our study that resulted in low survey effort per site. As such, it is difficult to compare our encounter rates to studies using different methods or with greater survey effort. The second was that we were not able to systematically assess the habitat structure and human disturbance at each site. Our qualitative data limited our ability to determine how human disturbance is impacting lemur species richness, occurrence, and abundance. It is the first, however, of a potentially longer-term study aimed to survey lemurs around the whole of Ankarafantsika National Park, and is a first step in meeting the proposal set out by Radespiel and Razafindramanana (2013) to (i) conduct continuous and long-term assessments of lemurs near 12 base camps situated around the park, and (ii) carry out additional rapid assessments to understand the changes to distribution and population structure of lemurs within it. We have provided baseline data at these sites and we have engaged with the communities and CLP at sites around the park, which can be used for future surveys and expanded monitoring efforts. To be successful, conservation efforts must engage community members directly in order to address direct and indirect causes of this conservation crisis and include development activities that help offset the high levels of poverty, considering the historical context and the cultural perspectives of community members engaged in activities that puts pressure on forests and lemurs.

Acknowledgments

We thank Jean Paul Soa, and the Comité Locaux des Parcs representatives, who assisted us in the research; Mamy Razafitsalama and Georges Marcellin, who provided logistical support; the Ankarafantsika National Park Director and Madagascar National Parks staff, who helped facilitate the project; the Ministère de l'Environnement et du Développement Durable; and all local community members who hosted us and supported our project. We are grateful to the following funding agencies: Primate Conservation Inc. (PCI#152), and IUCN SOS through Global Wildlife Conservation's Lemur Conservation Action Fund.

Ethical standards: All research, including our lemur surveys and questionnaires in this study abided by the national laws of Madagascar and was authorized and received ethical clearance by the Ministère de l'Environnement et du Développement Durable via permit No. 147/19/MEDD/SG/DGEF/DGRNE issued to Travis Steffens.

Supplementary material: Interview questions and Table SI - interview responses. Go to <http://www.primate-sg.org/storage/pdf/PC34_Suppl_mat_Steffens_et_al_Ankarafantsika.pdf>.

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Received for publication: 18 March 2020
Revised: 10 July 2020