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Assessment of wild ring-tailed lemur (Lemur catta) populations in southwestern Madagascar with implications for the illegal pet trade

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Assessment of wild ring-tailed lemur (*Lemur catta*) populations in southwestern Madagascar with implications for the Illegal Pet Trade

by

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Abstract

Accurate population estimates are critical to inform conservation management of species. Incomplete sampling can lead to population underestimates and lacking conservation efforts. Population surveys are important for assessing human and animal welfare to allow for targeted conservation action. Recent ring-tailed lemur (*Lemur catta*) surveys have led researchers to conclude that *L. catta* populations are crashing. This has generated much attention and alarm, but may also be based on incomplete information. To better understand population dynamics, more thorough sampling is needed. Here, we survey five such sites to reassess the presence and abundance of *L. catta* in these locations. We conducted rapid assessment surveys from June – July 2019 at five sites in southwestern Madagascar (Isalo National Park and Zombitse, Vohibasia, Ranomay, and Fiheranana forests) and detected a total of 121 *L. catta* from 14 groups at four of the five sites surveyed. Group sizes were within the normal range of variation from other published studies, and social organization seems intact. Of these populations, one appears to be well protected by the local community, while others are experiencing pressures from human hunting and encroachment. Our findings contribute essential information to population estimates, and build upon existing data to further refine *L. catta* distributions. Moreover, results from our study will allow for targeted conservation in areas where *L. catta* are threatened by human activities.

Key words: sweep surveys, primate, population estimates, conservation

Introduction

Ninety percent of lemur species are classified as at least vulnerable by the International Union for Conservation of Nature (IUCN red list; Andriaholinirina et al., 2014;). Recent declines in lemur populations are largely due to primary vegetation loss over the past 60 years; this has had detrimental effects on Madagascar's ecosystems, and is expected to increase unless drastic measures are taken (Vieilledent et al., 2018). The illegal trade of lemurs has also become increasingly widespread, with estimates suggesting as many as 28,000 lemurs are being kept as pets throughout Madagascar as of 2010 (Reuter et al., 2016). Capture for the pet trade has led to overexploitation of lemur populations that are already experiencing severe declines due to habitat loss and fragmentation (LaFleur et al., 2016). Scientists believe that the combined effects of forest loss and unsustainable hunting for capture and trade are driving lemur extinctions, ring-tailed lemurs in particular (LaFleur et al., 2016). The ring-tailed lemur (*Lemur catta*) had historically been widespread across southern Madagascar (Goodman et al. 2006). However, like all of Madagascar's fauna, *L. catta* face rapid population declines attributed to severe habitat loss and threats due to capture and overexploitation for the illegal pet trade (LaFleur et al., 2016).

Deforestation in Madagascar

Since 1953, Madagascar has lost 44% of its natural forest cover (Vieilledent et al., 2018). This trend continues unabated, with forest loss reaching 99,000 ha annually between 2010 and 2014 (Vieilledent et al., 2018). The rate of deforestation is also escalating. Annual forest loss has risen from 0.5% between 2005 – 2010, to 0.9% between 2010 – 2013 (Rakotomala, 2013), and most recently, up to 1.1% forest loss has occurred annually since 2014 (Vieilledent et al., 2018). Deforestation has broad negative impacts on lemur species as it degrades habitat quality, and

fragments natural forest, leaving species with little to no preferred habitat. Nearly half of remaining forests exist in patches (less than $500km^2$), 46% of which now lie within 100 m from the forest edge (Harper et al., 2007; Vieilledent et al., 2018). Furthermore, 22% of these remaining forests are considered highly fragmented with 40% or less canopy cover (Vieilledent et al., 2018). The increasing trends in deforestation can be explained in part by Madagascar's growing human population, which is increasing the demand for agricultural land for subsistence farming and for wood fuel (Minten et al., 2013). There is a clear link between deforestation and population growth in Madagascar (Gorenflo et al., 2011), and considering the current annual growth rate of 2.8% (United Nations, 2015), it is likely that unless demands are met through other means, the pressures on forest ecosystems will persist.

For ring-tailed lemurs, deforestation plays a considerable role in population decline (LaFleur et al., 2016). Ring-tailed lemurs occupy the spiny and dry deciduous forests of southwestern Madagascar (Goodman et al., 2006; Jolly, 2003; Mittermeier et al., 1994). Since 1990, 28% of the spiny forests of southwestern Madagascar have been lost to anthropogenic practices (Harper et al., 2007). Compared to other habitat types (humid forest, dry forest and mangroves) Madagascar's spiny forests have the highest clearance rate in the country at 1.2% annual loss (Harper et al., 2007). Scientists anticipate that by 2080, ring-tailed lemur habitat will be reduced by 68% due to climate change alone, not accounting for the added anthropogenic pressures that are sure to follow (Brown & Yoder, 2015). The greatest reduction in spiny forest occurred near the city of Toliara in southwest Madagascar (Harper et al., 2007). Toliara is a popular spot for tourism and has been expanding in more recent years which has led to increases in forest clearing for wood fuel, and as a cultural consequence when claiming ownership of land (Ratsifandrihamanana et al., 2006). This land clearing has been detrimental to the lemur

populations in the region, and because Toliara is a popular spot for tourism, it is a hot-spot for finding captive lemurs kept as tourist attractions.

Pet trade

In addition to the threats of habitat loss and fragmentation, lemurs face overexploitation due to their capture for the illegal pet trade. An estimated 28,253 lemurs have been illegally held in captivity in Madagascar since 2010 (Reuter et al., 2016). Ring-tailed lemurs are at particular risk of capture as household pets because of their popularity with tourists. Reuter et al. (2016) found that 70% of surveyed sites across Madagascar reported the presence of pet ring-tailed lemurs, making it the most reported captive lemur (LaFleur et al., 2019). This could be indicative that ring-tailed lemurs make up a larger subset of household pets than other species across the country.

LaFleur et al. (2019) reported that half of captive ring-tailed lemurs were found in businesses and were used to increase tourism and profit. Hotels and local households also keep ring-tailed lemurs in captivity and charge a small fee for tourists to take pictures with, feed, and pet the lemurs (LaFleur et al., 2016; Reuter et al., 2016). However, lemurs do not do well in captivity and often live under poor conditions, either on ropes or housed in small cages, and are fed diets consisting of rice and human food that do not align with their natural diets (Reuter & Schaefer, 2016). Poor welfare and diet leads to poor health and possibly death of the lemurs with little to no veterinary care. This could lead to a cycle of hotels continually replacing deceased lemurs with those poached from the wild to boost tourist traffic, thereby overexploiting wild lemur populations.

Models have shown that capture rates may be sustainable in populations of 500 or greater individuals, however the current literature suggests that few of these large lemur strongholds remain (LaFleur et al., 2019). Additionally, deforestation and fragmentation of primary forests make lemur populations more accessible to human poaching (LaFleur et al., 2019; Reuter et al., 2016). While we know that these illegally captured lemurs are destined primarily for major tourist cities (LaFleur et al., 2019), we still do not have a clear picture about where they are coming from, nor which specific populations are most at risk for overexploitation. Until we have a clear picture of the size and locations of remaining ring-tailed lemur populations, we cannot assess which populations are most threatened by overexploitation.

Historical distribution and biogeography of Lemur catta

Ring-tailed lemurs (*Lemur catta*) are amongst the best recognized primate taxa in Madagascar, and therefore act as a flagship species for conservation. They live in multi-male, multi-female matriarchal groups of 9 – 22 individuals, with some groups reaching over 30 individuals (Gould et al. 2003; Gould & Sauther, 2016; Sussman, 1991; Pride, 2005). Population densities of ring-tailed lemurs vary widely, ranging from $5 ind/km^2$ to $300 ind/km^2$ (Sussman et al., 2006). Upon reaching sexual maturity, dispersal is male-biased to increase chances of mating and genetic diversity across groups (Sussman, 1991; Sauther, 1999).

Although they are found mainly in the spiny forest and dry forest habitats of Madagascar (Goodman et al., 2006; Jolly, 2003; Mittermeier et al., 1994), ring-tailed lemurs are a generalist species, showing flexibility in both their habitat and diet preferences (Gould, 2006; Sauther et al., 1999). They are also the most terrestrial of the lemurs, allowing them to disperse across a variety of landscapes, not being limited to travel in dense forests (Goodman et al., 2006). Due to their

generalist nature, ring-tailed lemurs live in a variety of habitats and have historically been widespread across the southern third of Madagascar (Goodman et al., 2006).

Generalist species have a survival advantage over specialists; should one resource become scarce, generalists have flexibility to utilize another. This includes both habitat and food resources. The generalist nature of the ring-tailed lemur has provided a survival cushion, allowing them to live in degraded habitats (Gould & Gabriel, 2015); however, the severe habitat loss in Madagascar leaves ring-tailed lemurs with resources below critical thresholds for widespread survival (Sauther et al., 1999; LaFleur et al., 2017).

Current population estimates and survey methods

Recent surveys identified only a handful of remaining *L. catta* strongholds relegated to small forest fragments in southern Madagascar, estimating that fewer than 2,000 – 2,400 individuals remain in the wild (Gould & Sauther, 2016; La Fleur et al. 2016). These reports garnered significant media attention and led to the species' inclusion among the world's "Top 25 Most Endangered Primates" (Schwitzer et al., 2018). More recently, however, Murphy and colleagues (2017) reported that these surveys potentially underrepresent true *L. catta* counts, pointing out an additional 45 historical *L. catta* populations not accounted for in these recent estimates. They went on to argue that the recent studies' sweeping claims were based, in part, on data from sites that have not been surveyed in over 10 years, that the surveys do not cover a broad enough geographic distribution, and that their conclusions suffer from a lack of direct scientific observation (Murphy et al., 2017). They instead called for widespread systematic re-surveying of sites with historical *L. catta* presence.

The survey methods employed by LaFleur et al. (2016) and Gould & Sauther (2016) rely primarily on a review of the literature, and only secondarily on direct observation and personal communication to assess ring-tailed lemur populations. While literature can provide a valuable starting point, many reports are from ten or more years ago, leaving a large margin of error for populations to increase or decrease over time (Murphy et al., 2017). Combining an array of survey methods from a literature review also violate the assumptions of both parametric and non-parametric statistical analyses making it nearly impossible to calculate valid population estimates (Zimmerman, 1998). It is well known that different survey methods yield drastically different primate density calculations (Plumptre & Cox, 2006; Plumptre et al., 2013; Peres, 1999). Widespread primate surveys are difficult to complete (Sterling & Ramaroson, 1996), and density surveys often take years, meaning many primates may not actually benefit from long data collection periods.

Long term population data are ideal when determining population densities and population changes over time, however that is not always a viable option (Sterling & Ramaroson, 1996). Line transect surveying is the most commonly used method for determining primate population density estimates. Population densities are calculated by multiplying sampling density by total area being surveyed (Plumptre & Cox, 2006). This calculation varies depending on what data were collected at the time of the survey, making it challenging to standardize a primate survey method, let alone extrapolate from the literature. While long-term sampling efforts are needed to determine primate densities and abundance, ten day rapid assessment surveys can provide accurate species counts and species richness (Sterling & Ramaroson, 1996). Rapid assessment surveys allow conservationists to gain an understanding of local primate populations quickly and can inform conservation initiatives faster than long-term primate density surveys (Sterling & Ramaroson,

1996). Additionally, rapid assessment surveys may be a more practical technique to cover larger geographical areas (Sterling & Ramaroson, 1996; Gibbons et al., 2009).

The lack of reliable information regarding *L. catta* population distributions and target populations for illegal capture can be detrimental to conservation. Accurate population surveys inform us on which populations and regions are most at risk of local extinction and therefore where to focus limited conservation resources. Should conservation efforts focus only on the narrowly defined *L. catta* distribution put forward by Gould & Sauther (2016) and LaFleur et al. (2016), populations that exist outside of this range will be at continued risk. Thus, it is critical to attain data that can be employed to inform conservation management of this flagship species, before it is too late. It is imperative that sites be systematically resurveyed to obtain more accurate *L. catta* population counts and gain a more thorough understanding of remaining *L. catta* geographic distributions.

Specific Aims

Many of the historical *L. catta* localities appear to have maintained viable habitat for the lemurs and it is likely that populations may still be present (Murphy et al., 2017). However, the majority of these sites have remained unsampled in the last 10 years and thus present the possibility that *L. catta* strongholds may not be as limited as the current literature suggests. The specific aim of this study was to therefore survey five sites where *L. catta* were historically present to determine 1) whether populations still remain, and if so, 2) estimate population abundances in these locations.

Methods

Sites and study species

We conducted rapid assessment surveys from June – July 2019 at five sites in southwestern Madagascar: Isalo National Park (22°28’11.85”S, 45°15’38.35”E); Zombitse forest of Zombitse-Vohibasia National Park (22°45’0.00”S, 44°37’0.00”E); Vohibasia forest of Zombitse-Vohibasia National Park (22°45’0.00”S, 44°37’0.00”E); Ranomay (23°34’28.73”S, 44°19’41.53”E); and Fiheranana (23°14’0.00”S, 43°52’0.00”E)(Figure 1). Although Vohibasia forest is formally protected within the Zombitse-Vohibasia National Park (LaFleur et al., 2016; Gould & Sauther, 2016), it lies 20 km east of Zombitse forest; these two sites were therefore treated as separate sites for the purposes of our study.

Each site was sampled for a minimum of five days, except Isalo National Park which was surveyed for four days. These sites all have historical presence of *L. catta* and were chosen as high priority sites to resurvey based on currently inconclusive or deficient population data (Figure 1). Surveys were planned at a sixth site, Ranobe (22°48’0.00”S, 43°43’60.00”E), however we were unable to access this location due to local unrest.

Survey methods

Working with local guides, we conducted rapid assessment surveys at each of the five sites. Methods involved four observers walking established trails at a constant rate, stopping frequently to look and listen for *L. catta.* Upon detection, we noted the time and method of detection (visual, vocal, other), GPS location of the area where animals were first observed, and group size, when possible. We then remained with the group at a minimum distance of 10 m until we were able to more confidently record group size and demographics, such as sex and age. Not all animals could be reliably sexed because of the distance maintained between observers and lemurs; however,

juveniles could be distinguished from adults based on notable differences in body mass. During this time, we also noninvasively collected and preserved 276 fecal samples in 30 ml/sample of silica gel from across sampling localities (mean= 91 samples/locality) for later population genetic analysis in Hunter College's Primate Molecular Ecology Lab (Calkins & Baden, unpublished data). Permissions for research were obtained from the Madagascar government, MNP (#156/19), and the Hunter College Institutional Animal Care and Use Committee (IACUC) (AB WildPet 4/22).

Results

During our survey efforts, we detected a total of 121 *L. catta* from 14 groups at four of the five sites surveyed (Tables 1, 2); Fiheranana (N= 40), Ranomay (N=48), Vohibasia Forest (N= 10), and Isalo National Park (N=23). At Fiheranana (23°14'0.00"S, 43°52'0.00"E) a total of 5 groups were detected, totaling 40 individuals across groups. Ranomay (23°34'28.73"S, 44°19'41.53"E) was surveyed finding a total of 48 individuals across 5 groups. At Vohibasia (22°45'0.00"S, 44°37'0.00"E) 2 groups were detected and a total of 10 individuals were counted. Surveys at Isalo National Park (22°28'11.85"S, 45°15'38.35"E) yielded 2 groups with a total of 23 individuals (Table 2).

Average group size was 8.6 individuals per group, with group sizes ranging between 2 and 16 juveniles and adults. No infants were observed, as surveys occurred outside of the reproductive season, which generally occurs between August and September (Koyama et al., 2001). No animals were observed at Zombitse National Park; however, local park guides and community members verbally confirmed the presence of *L. catta* at this site, stating that they have seen them crossing the road to access other areas of the park.

Discussion

Results from our rapid surveys confirm the presence of ring-tailed lemurs (*L. catta*) at four of the five sites we surveyed, including three (Vohibasia, Fiheranana, Ranomay) that have been overlooked in the last decade (Gardner et al., 2009; Rasoarimanana, 2008; Siers, 2007). These observations expand the confirmed presence of *L. catta* into areas that were previously either unrecognized by La Fleur et al. (2016) and Gould and Sauther (2016) or considered 'likely locally extinct,' and add an additional 121 animals to current population estimates.

Of the sites visited during our surveys, *L. catta* in Zombitse and Vohibasia had been considered 'likely locally extirpated' due to their purported absence from Zombitse forest during earlier surveys of the park (La Fleur et al. 2016; Gould and Sauther 2016). It is important to note, however, that Zombitse-Vohibasia National Park is a large complex (36,308 hectares) of three sites that includes Zombitse (16,845 hectares), Vohibasia (16,170 hectares) and Isoky Vohimena forests (3,293 hectares), habitats that are separated by at least 20 km of non-continuous forest. Such nuances in park gazetting and discontinuities in habitat can be important when extrapolating population estimates, as species absences from one area may not be indicative of absences from the entire region (Angermeier et al., 2002). Thus, in this particular case, the absence of *L. catta* from Zombitse forest in earlier studies did not necessarily preclude its presence in the complex as a whole. To this point, our surveys – like those of La Fleur et al. (2016) – did not detect *L. catta* in Zombitse forest, suggesting that the Zombitse forest *L. catta* population exists at very low densities, if it exists at all. There are, however, local reports of *L. catta* crossing roads near the park entrance, suggesting that they are not yet locally extinct. By contrast, we confirmed the presence of *L. catta* at Vohibasia, a forest located 20 km to the northeast of Zombitse. This site had not been surveyed for *L. catta* since 2007, and even then, its presence was only detected via

vocalizations (i.e., no direct observations were made of the species; Siers, 2007). Here, we identified the presence of 10 animals through direct observation. While animals were skittish (see below) and population counts low, our observations extend the current known geographical range of *L. catta* to include Vohibasia and demonstrate species persistence in this region, albeit at low densities. These findings should act as a cautionary reminder that both survey extent and habitat variability must be taken into consideration when conducting rapid assessments, and that absence of evidence is not an indicator of species absence when extrapolating population estimates to larger areas. Although we did not visit Isoky Vohimena, it is possible that this third and final site in the Zombitse-Vohibasia National Park complex may also contain *L. catta*, a possibility that warrants further investigation.

Similarly, the Fiheranana *L. catta* population was also considered 'likely locally extirpated' by Gould and Sauther (2016), probably due its low population densities and hunting pressures described by Gardner et al. (2009). However, our survey results found 40 individuals belonging to 5 groups, with additional *L. catta* populations suspected to occur along the Fiheranana River Valley that extended beyond our survey's range. Future surveys to assess this possibility are warranted to further refine population estimates in this area.

Finally, our resurvey efforts confirm that Ranomay, an historic *L. catta* stronghold (Murphy et al. 2017), still supports a substantial *L. catta* presence. Although it is unclear why Ranomay was not included in earlier population estimates (Gould and Sauther 2016; LaFleur et al. 2016), we are confident that our estimates from this site represent a total population count due to our survey extent ($13km^2$), and to verbal confirmation provided by local guides (i.e., guides informed us that we had contacted all known groups in the area).

In addition to revising species occurrences, our survey efforts further contribute toward refining total and regional population counts. Here, we add new information from the previously unsurveyed Piscine Naturelle and 'data deficient' Namaza circuits (LaFleur et al., 2016) at Isalo National Park. Prior to our surveys, 118 individuals had been surveyed at the Maki Canyon site (LaFleur et al., 2016). Here, we add an additional 23 individuals, and suggest that greater numbers likely exist beyond these locations; however, researchers are only allowed to use trails already in existence, making surveys in other areas of the park impossible. Its vast size ($815 km^2$) suggests that many more *L. catta* may exist. However, massive fires have recently ravaged large areas of the park, making it unclear how much of the 815 km^2 protected area is still habitable by *L. catta* (Vyawahare, 2019). Unfortunately, although Isalo is a well-known tourist destination, detailed studies of *L. catta* at this site are not recorded in the recent literature. Further information is desperately needed from this region, as it could greatly impact our understanding of *L. catta* population viability there.

According to Murphy et al. (2017), *L. catta* presence was also previously confirmed at Ranobe (22°48'0.00"S, 43°43'60.00"E) – a site located in the Mikea forest region, near Ifaty. Although we intended to resurvey this site, and received local confirmation that *L. catta* was still present therein, we were unable to survey this location due to safety concerns. This is a problem for many rural parts of Madagascar, where a general lack of governance and conflict are threatening Malagasy flora and fauna (Dudley et al., 2002). Future studies should aim to visit this site to further elucidate species presence and abundance, while also working toward establishing more positive relationships with local communities.

While the lemur pet trade is extensive and unquestionably harmful to lemur populations (Reuter et al., 2015), we did not encounter any pet lemurs in villages surrounding the sites we

visited. We did not ask whether locals hunted lemurs for subsistence to avoid harming the vital rapport with our hosts. However, local guides at Fiheranana described an expatriate who occasionally comes to the forest to hunt *L. catta*, and pays the local guides as trackers. The lemurs here spent the majority of their time up steep escarpments that rise from the riverbed below, which are hard for people to access, and they tend to flee when humans approach, supporting these hunting claims. While we were not explicitly told of any hunting of lemurs at Vohibasia, previous work has indicated that hunting does occur in the village (Siers, 2007). Additionally, on multiple occasions there, our guide removed snares meant for wild fowl, which could be indicative that hunting for lemurs may also occur. The lemurs at Vohibasia also avoided human contact, retreating high into rocky outcrops at the first sign of humans. By contrast, the local villagers and guides at Ranomay took pride in their wildlife and were by far the most excited by the research we were conducting. The animals here are protected by members of the community who also enforce laws against cutting down the forest. The animals observed in Ranomay were less afraid of humans, and would often continue feeding in trees for some time while we observed them. Finally, lemurs at Isalo National Park are well protected and are unusually bold around humans, as they are acclimated to tourists getting close, and even feeding them.

Together, these observations suggest that conservation strategies in these areas must be targeted toward the particular needs and challenges posed to both the local people and wildlife (Borgerson et al., 2016). For instance, conservation initiatives at sites like Ranomay, where people have general positive feelings toward wildlife, may include facilitating local research initiatives and increasing ecotourism infrastructure to help maintain and bolster wild *L. catta* populations (Buckley, 2014; Borgerson et al., 2016). At sites such as Vohibasia and Fiheranana, where hunting is still likely to occur, conservation efforts might instead aim at education programs (Dolins et al.,

2010) and initiatives to promote alternative food sources to improve food security (Borgerson et al., 2018), to decrease the pressure of hunting on lemurs and other fauna in the region.

On a positive note, groups identified in our study were moderately sized (ranging from 2 to 16 individuals), with an average group size of 8.6 individuals. Notably, six groups numbered 9 or more individuals. This is comparable to group sizes reported from long-term studies, which ranged between 9 and 22, and up to as many as 30 individuals (Gould et al. 2003; Gould & Sauther, 2016; Sussman, 1991; Pride, 2005), suggesting that *L. catta* social organization remains intact in these parts of their range. Furthermore, previous work has found that groups with fewer than 5.5 individuals experience significant increases in cortisol levels than larger groups, suggesting that smaller groups may have greater difficulty defending resources and/or be less likely to detect predators, and thus have lower fitness outcomes (Wrangham, 1980; Pride, 2005). Eleven of the fourteen groups surveyed here contained greater than 5 individuals suggesting that the majority of groups we encountered were above the minimum group-size threshold associated with increased stress.

While our results are encouraging, additional surveys are still needed to improve population estimates. We acknowledge that results from our rapid assessment are by no means able to provide accurate estimates of total *L. catta* population size. Rather, the purpose of these assessments is to shed light on the vast deficiency of information regarding *L. catta* population estimates, and to confirm the presence of additional *L. catta* populations across their historic range. As conservationists, it is crucial that we do not confuse data deficiency with population deficiencies. Accurate population estimates are critical to inform conservation management of species, and it is therefore critical that additional sampling occur beyond the regions included in this study. While we agree with the sentiments offered by Gould and Sauther (2016) and La Fleur

et al. (2016) – that Madagascar's endemic species, including *L. catta*, are facing insurmountable threats pushing them toward extinction— *L. catta* may, in fact, be more broadly distributed than population estimates currently suggest. More comprehensive information on their densities and distributions is desperately needed to better manage and protect wild *L. catta* populations.

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Figures and Tables

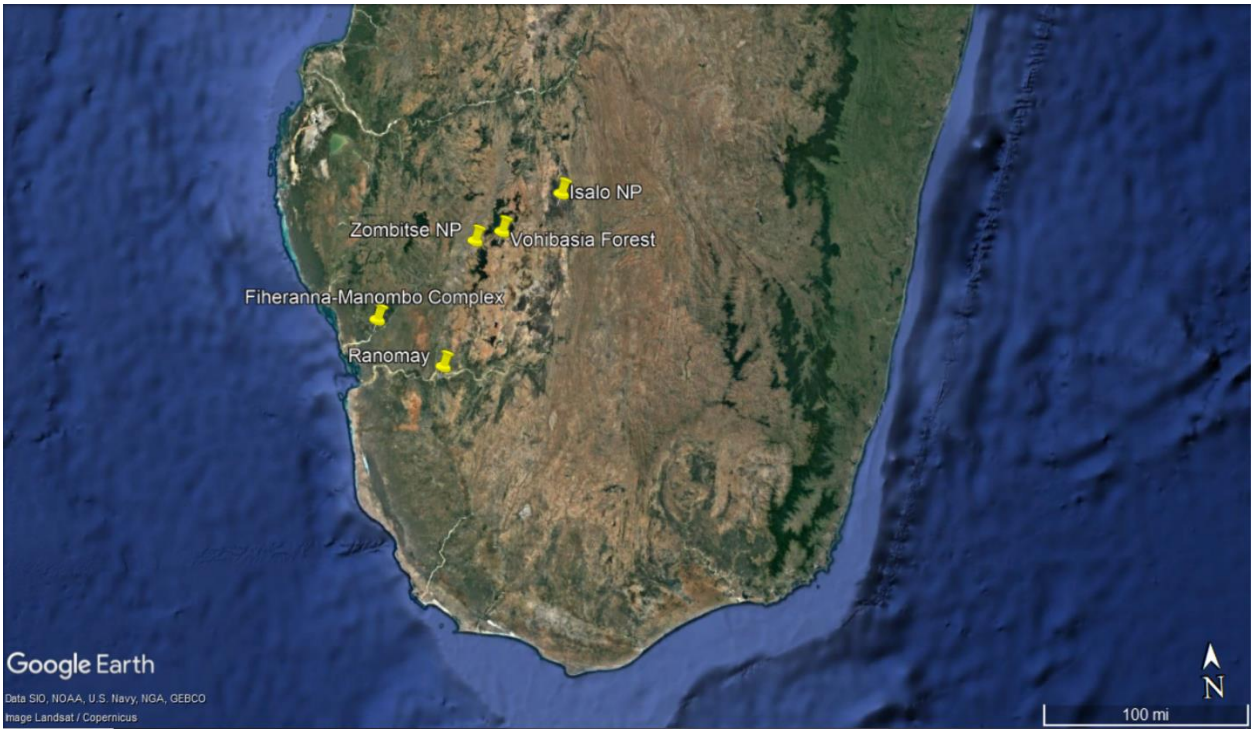

Figure 1. Map illustrating five survey sites of *Lemur catta* in southern Madagascar: Isalo National Park, Zombitse National Park, Vohibasia Forest, Fiheranna-Manombo Complex, and Ranomay. Sites were surveyed for presence of *Lemur catta*. These sites all have historical presence of *L. catta* and were chosen as high priority sites to resurvey based on currently inconclusive or deficient population data.

Table 1. Locations of six proposed sites of ring-tailed lemur survey in Southwestern Madagascar.

Site name	Latitude	Longitude	Present?	Total population sampled?	N groups	N individuals
Vohibasia Forest	22°42’0.00”S	44°49’0.00”E	Yes	No	2	10
Zombitse National Park	22°45’0.00”S	44°37’0.00”E	Yes*	-	unk	unk
Fiheranana	23°14’0.00”S	43°52’0.00”E	Yes	Yes	5	40
Ranomay	23°34’28.73”S	44°19’41.53”E	Yes	Yes	5	48
Isalo National Park	22°28’11.85”S	45°15’38.35”E	Yes	No	2	23
Ranobe	22°48’0.00”S	43°43’60.00”E	Yes*	-	unk	unk

***** denotes sites with verbal confirmation from local guides that *L. catta* is present; future surveys are needed to assess its population status at these site

Table 2. *L. catta* group location and size at surveyed sites in southwestern Madagascar.

Site- Group	Latitude	Longitude	Group Size
Vohibasia-1	22 42’ S	44 49’ E	8
Vohibasia-2	22 41.183’ S	44 49.601’ E	2
Fiheranana-1	23 13’ 59.6’’	43 52’ 36.9’’	14
Fiheranana-2	23 13’ 25.0’’ S	43 52’ 50.6’’ E	2
Fiheranana-3	23 13’ 28.0’’ S	43 53’ 59’’ E	7
Fiheranana-4	23 13' 43.9" S	43 52' 56.1" E	6
Fiheranana-5	23 13' 15.6" S	43 54' 27.4" E	11
Ranomay-1	23 35’ 04.9’’ S	44 19’ 15.1’’ E	7
Ranomay-2	23 34’ 00.1’’	44 20’ 09.1’’	13
Ranomay-3	23 33’ 57.7’’	44 19’ 57.9’’	16
Ranomay-4	23 34.320’ S	44 20.153’ E	5
Ranomay-5	23 33’ 56.9’’ S	44 20’ 13.7’’ E	7
Isalo-1 [a]	22 32' 21.3" S	45 22' 47.5" E	14
Isalo-2 [b]	22 33' 43.3" S	45 22' 58.5" E	9

[a] Namaza Circuit group
[b] Piscine Naturelle group