

# A Re-evaluation of the Northern Sportive Lemur (*Lepilemur septentrionalis*) Population at Montagne des Français, and a Review of Its Current State of Conservation in the Protected Area

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**Abstract:** The northern sportive lemur (*Lepilemur septentrionalis*) is one of the most endangered primates in the world. Surveys from 2012 and 2013 identified only 52 individuals, all occurring in small, isolated forest fragments within its historic range. Further exacerbating the issue, the ever-increasing human population of the nearby city of Antsiranana is driving demand for biofuel, which is supplied by the production of charcoal from the forests of Montagne des Français, where the biggest remaining population of northern sportive lemurs resides. Despite the designation of Montagne des Français as a protected area in 2015, illicit anthropogenic activities persist, threatening the remaining population of this Critically Endangered lemur. Omaha's Henry Doorly Zoo and Aquarium and the Madagascar Biodiversity Partnership conducted two month-long surveys in Montagne des Français to obtain a current population estimate of *L. septentrionalis* and approximate focal locations for future conservation initiatives for the species. Our surveys identified 87 individuals in Montagne des Français, almost all of them restricted to the central forest fragments, with northern sportive lemurs being absent or near absent in the northern and southernmost parcels. It appears the population in this region has increased in the last six years, possibly because of the creation of the protected area and the efforts of Omaha's Henry Doorly Zoo and Aquarium and the Madagascar Biodiversity Partnership in collaboration with the regional gendarmerie and officials under the Direction Régionale de l'Environnement et du Développement Durable of the Diana region to patrol the forests and prevent anthropogenic destruction. However, it is also possible that this increase is artificial due to the loss and fragmentation of their forest, causing the lemurs to be more densely populated in the remaining forest patches than has been evident in previous studies. Regardless, results of this survey suggest that northern sportive lemurs should remain listed as Critically Endangered, and effective protection of this species will require further research, along with habitat restoration and regular patrolling by local enforcement to prevent further degradation of the remaining forests.

**Keywords:** *Lepilemur*, northern sportive lemur, Montagne des Français, population assessment, rapid survey

## Introduction

Anthropogenic disturbance has led to lemurs becoming the most threatened group of mammals on the planet (Schwitzer *et al.* 2014). In December 2019, thirty-eight of Madagascar's 111 lemurs were listed as Critically Endangered on the IUCN Red List, nine of them sportive lemurs, genus *Lepilemur* (IUCN SSC Primate Specialist Group, January 2020). Unlike many of the lemurs, those of the genus *Lepilemur* do not survive well in captivity (Petter *et al.* 1977), likely because of their complex diet and strict energy budget (Nash 1998;

Dröscher *et al.* 2016). With Madagascar having the highest deforestation rate in the last century of any country that has native non-human primates (Harper *et al.* 2007) and considering that lemurs are the most sensitive to habitat change (de Almeida-Rocha *et al.* 2017), sportive lemurs are in dire need of conservation action.

Arguably the most endangered of the sportive lemurs is the northern or Sahafary sportive lemur (*L. septentrionalis* Rumpler and Albignac, 1975; Fig. 1). Originally believed to be distributed across far northern Madagascar, from Montagne d'Ambre south to the Mahavavy River, close to Ambolibe



**Figure 1.** *Lepilemur septentrionalis* at Montagne des Français, Madagascar. Photo by Aubin Andriajaona.

(Hawkins *et al.* 1990; Rumpler *et al.* 2001), the designation of *L. ankaranensis* Rumpler & Albignac, 1975, as a unique species, reduced the range of *L. septentrionalis* to a few small forests in the Sahafary region (Rumpler 2001; Ravaorimanana *et al.* 2004; Mittermeier *et al.* 2010; Wilmet *et al.* 2014). In 2007, a survey in the forests of Sahafary and Analalava estimated a population size of 100 *L. septentrionalis* (see Ravaorimanana *et al.* 2009). A follow-up survey in 2012 and 2013 conducted by Omaha's Henry Doorly Zoo and Aquarium (OHDZA) and the Madagascar Biodiversity Partnership (MBP) located only three individuals in the forests of Sahafary and Analalava, suggesting severe population declines in these areas (Louis and Zaonarivelo 2015).

In 2010 and 2011, OHDZA and MBP caught eight sportive lemurs in Montagne des Français and, through morphometric and molecular analysis, later confirmed that they were *L. septentrionalis*, thus expanding the known range of the species (Ranaivoarisoa *et al.* 2013). Surveys completed in 2012 and 2013, again by OHDZA and MBP, found a combined total of 49 individuals at Montagne des Français (Louis and Zaonarivelo 2015; Fig. 2). It is likely that Montagne des Français is the largest remaining stronghold for the species.

In 2015, the conservation of the northern sportive lemur benefitted from the granting of full protected status to Montagne des Français by the government of Madagascar, with the Service d'Appui à Gestion de l'Environnement (SAGE) acting as the management authority for the region (Goodman *et al.* 2018). In addition, a community-based organization responsible for forest management, known as Vondron'Olona Ifototra, was formed in Andavakoera, the principal village near Montagne des Français. Unfortunately, charcoal production and tree felling for lumber, cattle grazing, and slash-and-burn agriculture remain a problem despite the protected status of the area (Goodman *et al.* 2018; Fig. 3). Previous studies at Montagne des Français have indicated that anthropogenic pressures are being driven by the demands of the growing population of the city of Antsiranana (D'Cruze *et al.*

2007; Sabel *et al.* 2009). Between 1993 and 2018, the population nearly tripled (INSTAT 2019), and the illicit practice of charcoal production from Montagne des Français is largely attributed to supporting this expanding city (Sabel *et al.* 2009; Ranaivoarisoa *et al.* 2013; Goodman *et al.* 2018).

Given that anthropogenic disturbance continues despite the protected status of Montagne des Français and that a population census of *L. septentrionalis* has not been conducted since 2013, OHDZA and MBP initiated a follow-up rapid-assessment survey for the species. We present here the results of two month-long surveys in Montagne des Français and, based on these findings, an updated status of the *L. septentrionalis* population in the reserve, and suggest conservation strategies that can be applied in other locations across Madagascar.

## Methods

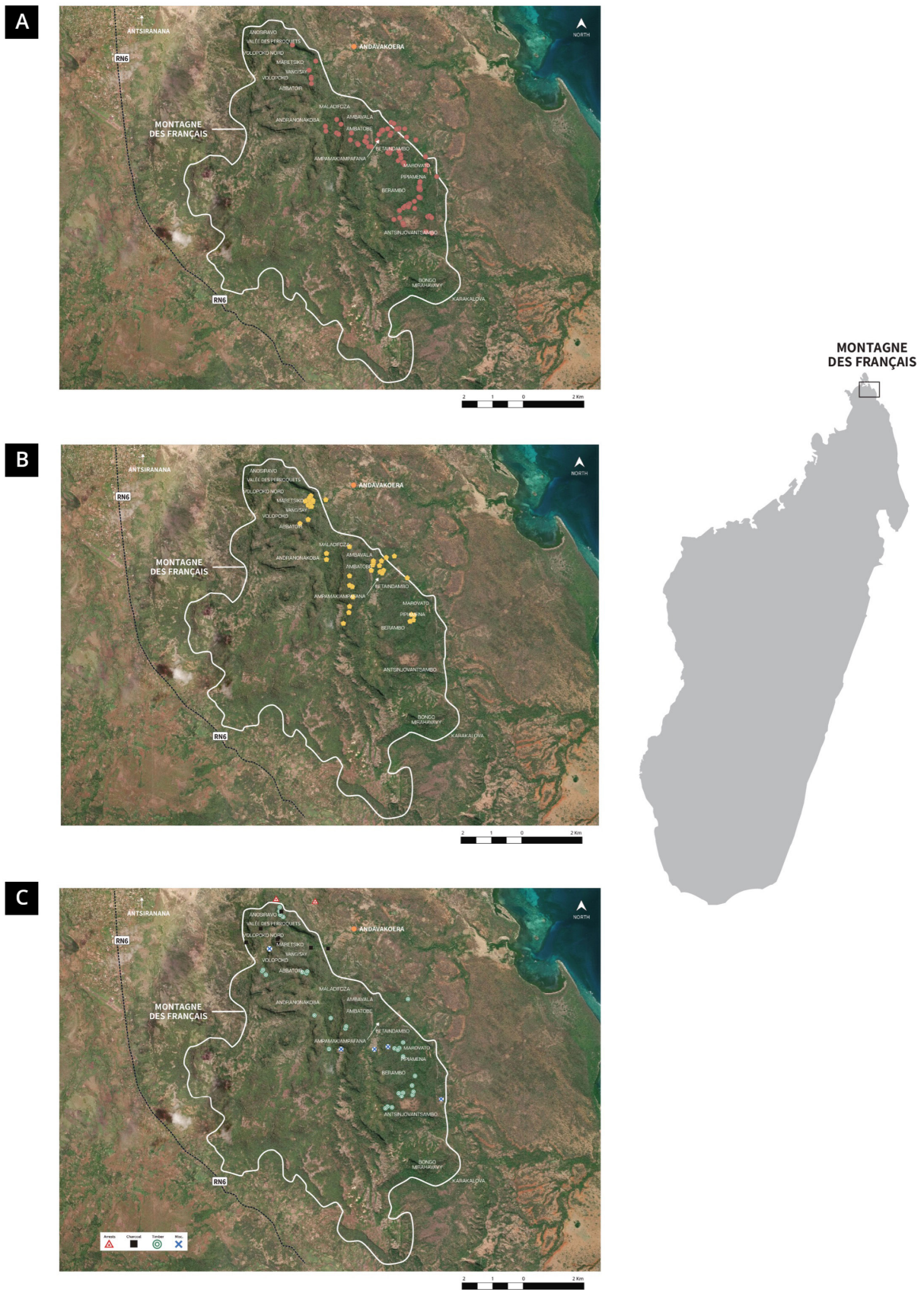
### Study site

Montagne des Français (12°20'02.7"S, 49°21'21.9"E), a protected area of about 6,100 ha, is located 12 km southeast of Antsiranana, a seaport city in northern Madagascar (Goodman *et al.* 2018). The vegetation type of the Montagne des Français massif is transitional from mid-altitude rainforest to western dry deciduous forest (Ramanamanjato *et al.* 1999; Moat and Smith 2007). As a result of slash-and-burn agriculture, cattle grazing, logging, and charcoal production, the remaining habitat in the area is greatly disturbed, leaving mainly forest patches that are surrounded by shrub or grassland (Sabel *et al.* 2009; Goodman *et al.* 2018). The vast majority of these remaining forest fragments are in the eastern and northern portions of Montagne des Français. There are no habitats in the south, central and western portions of the protected area that could seem to support sportive lemur populations (Schwitzer *et al.* 2013; E. E. Louis, Jr. pers. comm.). These areas have been most heavily impacted by anthropogenic disturbance due to their proximity to Route Nationale 6, which goes directly to Antsiranana.

### Survey Methods

Surveys were conducted in August and September 2019 by one four-person and one five-person team, respectively. The teams were accompanied by three gendarmes during the surveys since ongoing illegal activities such as charcoal production have created security issues within the protected area. Broad survey methods (NRC 1981; Sussman *et al.* 2003) were used to record *L. septentrionalis* along 24 trails in the various forest fragments, typically with one team member walking 5-m out on either side of the trail, and the remaining team members walking along the trail. Teams walked at a pace of approximately one kilometer per hour, using headlamps to identify northern sportive lemurs in the forest fragments. For nearly every individual sportive lemur identified, a GPS point was recorded using a handheld Garmin GPSMAP unit. Except for an inter-observer reliability test (described below) on one trail, the trails were walked just once to avoid recounting individuals. We used ArcGIS 10.7 (Esri 2019)





**Figure 2.** Three maps of Montagne des Français, Madagascar with labelled forest parcels. Map A portrays the August/September 2019 survey with red circles representing GPS locations of *Lepilemur septentrionalis*. Map B shows 2012–2013 surveys with yellow pentagons represent GPS locations of *Lepilemur septentrionalis*. Map C displays the locations of anthropogenic disturbance identified by DREDD DIANA, gendarme, and Madagascar Biodiversity Partnership patrols during 2019. Miscellaneous anthropogenic disturbances include camps, mineral excavation, and agricultural production.



**Figure 3.** Anthropogenic destruction at Montagne des Français, Madagascar in 2019. Photo by Aubin Andriajaona.

to visualize the spatial distribution of *L. septentrionalis* in Montagne des Français to support suggestions for future species-specific conservation strategies. All research was authorized by Madagascar's Ministry of the Environment and Sustainable Development (Permit 159/19/MEDD/SG/DGEF/DGRNE).

One trail was walked twice to conduct an inter-observer reliability test, to ensure that data collection methods between the two survey teams were comparable. In separate months, both teams surveyed the same forest fragment, Berambo, recording the *L. septentrionalis* encountered. A weighted occurrence agreement formula was used:

$$C\% = \frac{A}{A + B} * 100$$

where C% is the percentage of agreements, A the number of agreed observations, and B the number of differences in observation (House *et al.* 1981). The test indicated an 87% agreement rate, which is considered adequate, therefore all surveying is trusted to have been done in a reliable and consistent manner (House *et al.* 1981). The August survey for Berambo produced the greater count of individuals, therefore those numbers were used, along with all the surveys from the other forest patches, to estimate the population size.

## Results

The two-month survey resulted in a count of a minimum of 87 northern sportive lemurs observed in 12 of the 19 forest patches surveyed. Forest fragments where *L. septentrionalis* was found averaged seven individuals (range 1–20). The largest numbers were found in the forests of Betaindambo (20) and Berambo (15) (Table 1). Unfortunately, over 36% of the surveyed areas were devoid of any *L. septentrionalis*.

**Table 1.** Enumeration of *Lepilemur septentrionalis* encountered in forest fragments of Montagne des Français, Madagascar, during August and September 2019 surveys. In the case of Berambo, the highest number recorded of the two surveys is used for the overall count.

Closest Named Forest Fragment	Number of <i>L. septentrionalis</i>
Abattoir	3
Ambatobe	11
Ambavala	0
Ampamakiamafana	7
Andranonakoba	6
Anosiravo	0
Antsinjovantsambo	10
Berambo	15
Betaindambo	20
Bongo Mirahavavy	0
Karakavova	0
Maladifoza	0
Maretsiko	0
Marovato	10
Pipiamena	2
Vallée de Perroquet	1
Vangisay	1
Volopoko	1
Volopoko Nord	0
Total	87

## Discussion

Since the last surveys conducted in 2013, it appears that the population of northern sportive lemurs at Montagne des Français has seen a considerable increase, though not enough to justify improving its IUCN status from Critically Endangered. Although our result cannot be directly compared to the 2012–2013 assessment because of differences in the areas surveyed (Louis and Zaonarivelo 2015), when comparing just the forest patches surveyed in both studies (Abattoir, Andranonakomba, Ampamakiamafana, Ambatobe, and Berambo), there was an almost 56% increase, from 27 to 42 individuals observed. This could be indicative of one of two scenarios: (1) the northern sportive lemurs are persisting and thriving in Montagne des Français despite continued disturbance of their habitat, or (2) continued disturbance has caused the remaining populations of *L. septentrionalis* to be heavily concentrated in a few forest fragments; thus, misrepresenting the population improvement.



Some sportive lemurs, including the northern sportive lemur, are able to adapt and survive in habitats that have some degree of degradation (Dinsmore *et al.* 2016; Seiler *et al.* 2013, 2014). For example, *L. sahamalazensis*, a species with distinct habitat preferences, was able to adapt to some forest degradation in the Sahamalaza Peninsula, but continued deforestation will likely negatively impact the species (Seiler *et al.* 2013, 2014). Preliminary results from Dinsmore *et al.* (2016) suggested that the northern sportive lemurs at Montagne des Français were able to adapt to some anthropogenic pressures by altering their diet, feeding more on fruits than leaves, spending more time feeding, and increasing their home range. While the populations at Montagne des Français appear to be increasing in the short term, the degree of degradation that they can tolerate is unclear. It is likely that *L. septentrionalis* can withstand some habitat disturbance but would experience a population crash if disturbance became too great. The effects of habitat degradation on the northern sportive lemur should be examined further.

It is equally possible that, similar to *Propithecus diadema* in Tsinjoarivo (Irwin 2008), *L. septentrionalis* reaches higher densities in fragmented forests, as more individuals are consolidated into the remaining parcels. Anthropogenic pressures—timber and charcoal production—on the remaining forests at Montagne des Français have persisted despite it being granted protected status in 2015. Habitat destruction from known illicit activities is chronic in the northern parts that are closer to the city of Antsiranana (Sabel *et al.* 2009). During interviews with people living within the boundaries of Montagne des Français as well as villagers from nearby Andavakoera, Sabel *et al.* (2009) found that 78% of interviewees were involved in charcoal production, and 67% of them sold it in Antsiranana. The authors noted that, as a result, the more accessible areas in Montagne des Français had been cleared (Sabel *et al.* 2009). Established footpaths in the northern portion of Montagne des Français make these forest patches easy

to reach and thereby a prime target for exploitation. Based on the results of our survey, the northernmost and southernmost survey sites were either devoid of or had very few northern sportive lemurs, while the centrally located survey parcels contained the highest numbers (Table 1, Fig. 2). Of the lemurs recorded, 93% were from Andranonakoba south to Antsinjovantsambo, indicating a reduction in the viable habitat for this species.

As part of a conservation action plan for *L. septentrionalis* in Montagne des Français, OHDZA and MBP coordinated forest patrols with the regional gendarmerie and officials with the Direction Régionale de l'Environnement, et du Développement Durable (DREDD) DIANA beginning in 2017. The patrols were intended to stop illicit activities and deter future destructive behavior in the Montagne des Français. In 2019, there were multiple arrests regarding tree felling and charcoal production, with two people being sentenced to five years in jail (Aubin Andriaona, pers. comm.). These patrols have recorded illicit activities in the Volopoko Nord, Andranonakoba, and Anosiravo forest patches, as well as those of Berambo, Ambatobe, and Betaindambo, which unfortunately had the highest numbers of sportive lemurs observed in the surveys (Fig. 2, Table 1). Patrols conducted along the stretch of Route Nationale 6 that runs along the west side of Montagne des Français caught people transporting charcoal illegally without permits (Fig. 4), including one person who was transporting 259 bags of charcoal. The exact extent to which these patrols and subsequent arrests have benefitted the population of *L. septentrionalis* at Montagne des Français is uncertain, though the increase in the number of northern sportive lemurs observed during this most current survey compared to previous surveys, suggests that the patrols are helping.

With only 87 reported northern sportive lemurs at Montagne des Français, more work needs to be done to ensure the survival of this species, including research that can better guide future conservation actions. Besides a small population estimate, there is a lack of baseline ecological data on *L. septentrionalis*, needed for developing a species-specific conservation strategy (Sutherland 1998). To date, only one short-term study has explored the dietary behavior of this species (Dinsmore *et al.* 2016), and while it provides a good preliminary understanding of northern sportive lemur feeding behaviors, it lacks the duration required to understand the seasonal complexities of their diets. There have been no published studies that have explored the species' habitat requirements, such as the forest composition and availability of sleeping sites. *Lepilemur septentrionalis* is likely below the minimum viable population size needed for it to persist. Since minimum viable population sizes are context specific (Traill *et al.* 2007), accurate estimates cannot be created without the aforementioned ecological information.

Conservation initiatives for the species should focus on preserving these smaller forest patches and creating corridors between them. Though the population numbers appear to have increased, the fragmentary nature of the forests limits the dispersal of individuals and subsequently minimizes gene



**Figure 4.** Local gendarmes seize charcoal from a vehicle transporting it without permits. Photo by Diane Lolita Tsaliva.

flow, and thus genetic diversity (see, for example, Oklander *et al.* 2010; Baden *et al.* 2014). Protection and reforestation efforts need to be systemic, as no single fragment supports enough individuals to maintain a viable population. Unfortunately, there does not appear to be an immediate, mutually-beneficial solution to mitigate habitat loss for lemurs and meet the energy demands of the nearby city of Antsiranana. Until one is found, continued presence of law enforcement officials is the best option for limiting anthropogenic disturbance in these forest patches. This, of course, is not the most financially viable solution but may represent the only legitimate short-term solution here and for similar situations elsewhere in Madagascar.

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