Daraina sportive lemur (*Lepilemur milanoii*) density and population size estimates in most of its distribution range: the Loky-Manambato region

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Abstract

The population of the Daraina sportive lemur (*Lepilemur milanoii*) is believed to be mostly confined to the Loky-Manambato region (Louis *et al.,* 2006). Very little is known about *L. milanoii* and it is classified as "Data Deficient" by the IUCN (IUCN, 2013; Schwitzer *et al.,* 2013). Despite the management of the area by the NGO Fanamby since 2005, no study had been conducted to determine the presence and the abundance of *L. milanoii* in the main forest fragments of the region. During the 2011 dry season we surveyed the ten main forest fragments of the Loky-Manambato region and estimated *L. milanoii* densities and population sizes using line transect distance sampling (Buckland, 2001) and the DISTANCE software (Thomas *et al.,* 2010). The results suggest that sportive lemur densities are reasonably high in the region, but with important discrepancies between forest fragments, with densities ranging from 49.8 ind./km² in Antsaharaingy to 590.5 ind./km² in Ampondrabe. For the region Loky-Manambato we were able to estimate a population size of ~52,000 individuals. This is the first estimate for the total population size and we argue that similar studies should be repeated to monitor environmental changes and anthropogenic pressures (hunting, deforestation, mining, etc.).

Mots clés: *Lepilemur milanoii*, densité de population, distance sampling, Loky-Manambato

Résumé

Le lémurien *Lepilemur milanoii* est une espèce, dont on pense qu'elle est essentiellement présente dans la région Loky-Manambato (Louis *et al.,* 2006). C'est une espèce sur laquelle on possède très peu d'informations. En conséquence, *L. milanoii* est actuellement classé dans la catégorie «Data Deficient» (données insuffisantes) par l'UICN (IUCN, 2013; Schwitzer *et al.,* 2013). Malgré la mise en gestion des forêts de cette région par l'ONG Fanamby depuis 2005, aucune étude n'avait encore été menée dans les fragments forestiers de la région pour déterminer la présence et quantifier la taille des populations de Lépilemur. Nous avons visité les dix principaux fragments forestiers de la région durant la saison sèche de 2011. Nous avons estimé les densités et tailles des populations de *L. milanoii* en utilisant la méthode de «line transect distance sampling » (Buckland, 2001) et le logiciel DISTANCE (Thomas *et al.,* 2010). Les résultats suggèrent que les densités de Lépilémurs sont relativement élevées dans la région, mais avec de fortes différences entre fragments forestiers, allant 49.8 ind./km² à Antsaharaingy, à 590.5 ind./km² à Ampondrabe. Pour la région Loky-Manambato nos estimations suggèrent que la population pourrait compter 52,000 individus. Il s'agit de la première estimation de la taille globale de la population de cette espèce et nous pensons qu'il serait nécessaire de refaire des études similaires afin de mieux évaluer les effets des changements environnementaux et d'origine anthropique (chasse, déforestation, exploitation minière, etc.).

Introduction

The Daraina sportive lemur (*L. milanoii*) is a nocturnal lemur of the Lepilemuridae family. Its distribution range is thought to be mostly limited to the Loky-Manambato (Daraina) region in northern Madagascar (Louis *et al.,* 2006) even though these authors have also identified individuals living in sympatry with *L. ankaranensis* in the Andrafiamena forest. Till now neither its complete distribution range, nor its biology have been described. This lack of information is partly due to the remoteness of the region and to the nocturnal activity of the species. Despite its known distribution range being now protected, forest managers and scientists that visited these areas first focused their attention on the diurnal vertebrates (Quéméré *et al.,* 2010a, 2010b; Rakotondravony, 2009, 2006), on rodents (Rakotoarisoa *et al.,* 2010, 2013) and on the vegetation cover (Nusbaumer *et al.,* 2010; Ranirison *et al.,* 2010). Moreover, the Daraina sportive lemur is increasingly threatened by hunting, as the members of the family Lepilemuridae are usually easy to hunt during the day while they are sleeping in their tree holes. It is in this context that it seemed urgent to obtain basic data on their distribution and abundance. We present here the result of an extensive survey of the Loky-Manamabato region, providing *L. milanoii* (i) presence data, (ii) density and (iii) population size estimates.

Methods

Study site

The Loky-Manambato region in northern Madagascar is known to host the golden-crowned sifaka (*Propithecus tattersalli*). This eco-region is delimitated by the Loky river in the north, the Manambato River in the south and the Indian ocean on the East (Fig. 1). The region is crossed by the river Manankolana known to be a partial barrier for dispersal of *P. tattersalli* (Quéméré *et al.,* 2010b). The region covers 4 municipalities (Daraina, Ampisikina, Maromokotro and Nosibe), and belongs to the "sous-préfecture" of Vohémar in the Diego-Suarez province. The region is located at 12°45'S and 13°20'S latitude and 49°25'E and 49°55'E longitude (Ranirison, 2006). The ten major forest fragments of this region (Fig. 1) are mainly composed of dry deciduous vegetation. However, some mountainous forests harbor transition and humid evergreen vegetation (i.e. Binara and Antsahabe in

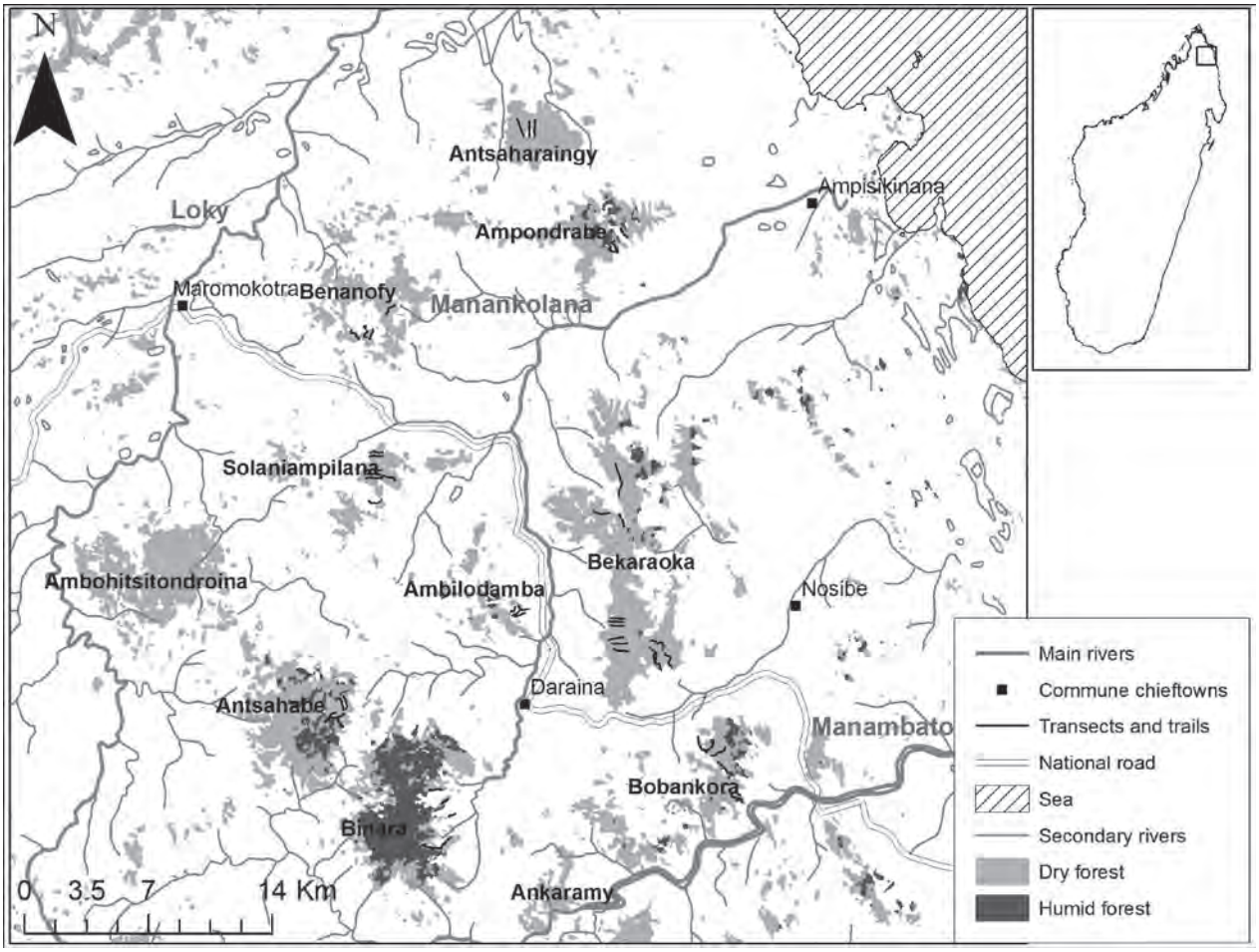

Fig. 1: Map of the Loky-Manambato region.

the south-west). Since 2005 the region is managed by the NGO Fanamby and classified as SFUM (Station Forestière à Usage Multiples, Multiple Uses Forest Station).

Density and population size estimates

To estimate population densities we conducted nocturnal line transect distance sampling survey (Buckland, 2001; Meyler *et al.,* 2012; Salmona *et al.,* 2013) commonly used for forest dwelling primates (Buckland *et al.,* 2010) and particularly well adapted for sportive lemurs (Meyler *et al.,* 2012). Each transect and trail marked by flags every 20 meter was surveyed two to four times by a two-member team walking slowly (at ~0.5 km/h) between 18:30 and 21:30. Every day one member from each group would change team, therefore reducing observational biases among observers (Buckland, 2001). Lemurs were located with the help of headlamps. A powerful hand torch was used to confirm the sighted species. Number of individuals, GPS position and estimated perpendicular distance and time of sighting were recorded. Safety concerns related to walking in uneven terrain at night prevented the use of tape measures to precisely measure perpendicular distances. To ensure accuracy and consistency in measurements and between observers, all observers underwent a distance estimates training session with measured distances before participating in the survey.

Obtained field data was analyzed using conventional distance sampling (Buckland, 2001; Kun-Rodrigues *et al.,* 2014) implemented in the Distance software (Thomas *et al.,* 2010). This approach explicitly models the decreasing probability of observing an animal as its distance from the transect increases. Various functions can be used to model this probability and estimate the effective strip width (ESW). Here we tested the uniform, hazard rate, half normal and negative exponential detection function and compared them using the Akaike Information Criterion (AIC). To avoid difficulties in fitting the tail of the detection function, we truncated the largest 5% of the data (Buckland, 2001).

We estimated population size by multiplying the density considered with the total surface of each corresponding forest fragment. Dry and humid forest were taken in account, using forest layers from the Madagascar Vegetation Mapping Project (Moat and Smith, 2007), available at **http://www.kew.org/gis/projects/mad_veg/datasets.html.** The global population size estimate, at the Loky-Manambato region scale takes in account all forests between the two rivers (Loky and Manambato), not only the ten main forest fragments visited.

Results and discussion

Our work first shows that all visited forest fragments from the Loky-Manambato region do host sportive lemurs, despite the important vegetation diversity amongst forests (Ranirison, 2006).

A total of 52 line transects of ~1 km were surveyed from April to November 2011 and 510 observations were recorded (Tab. I) for a total ~142km of survey efforts in 9 of the 10 major forest fragments of the Loky-Manambato region (Tab. I). Four of the nine forests surveyed with distance sampling (Ampondrabe, Bekaraoka, Bobankora and Solaniampilana) had enough sportive lemur sighting ($N \geq 40$), to accurately model independent detection functions. For the five other forests (Tab. I), we used the generic

Tab. 1: Sportive lemur densities and population sizes in the Loky-Manambato region.

Forest fragment	Type	Loc	#Tr	Total effort (km)	# obs	ESW **	Density (D)			Forest area (km²)	Population size (A)		
								95% CI				95% CI	
							D	Lower	Upper		A	Lower	Upper
Ambilondambo	D	L	3	2	4	11.0	63.0	8	479	8.30	523	69	3,974
Ambohitsitondroina	D	L			Present		*			38.32	6,019	4,579	7,913
Ampondrabe	D/T	L	3	7	91	10.1	590.5	125	2,789	22.76	13,440	2,845	63,484
Antsahabe	T/H	L	5	16	26	11.0	69.9	24	200	36.94	2,581	899	7,406
Antsaharaingy	D	L	3	7	9	11.0	49.8	3	847	13.66	680	40	11,567
Bekaraoka	D/T	R	15	48	215	12.1	183.5	147	229	62.48	11,466	9,173	14,334
Benanofy	D	L	4	17	21	11.0	58.1	12	271	25.17	1,463	314	6,826
Binara	T/H	L	4	6	26	11.0	170.3	23	1,277	45.64	7,772	1,036	58,291
Bobankora	T/H	R	8	25	53	11.6	90.3	55	148	16.04	1,449	886	2,370
Solaniampilana	D	L	7	14	65	12.2	186.2	110	314	22.23	4,139	2,452	6,987
Loky-Manambato region			52	142	510	11.0	157.1	119	207	334.78	52,588	40,003	69,133

Type: forest type (D: dry forest, T: transition forest, H: humid forest); Loc: location on the right (R) or left (L) side of the Manankolana river (see map); #: number of; Tr: transects and trails; obs: observations; ESW: effective strip width; CI: confidence interval; *: Ambohitsitondroina population size was estimated using the average sportive lemur density of the Loky-Manambato region; **: bold ESW indicates that the number of observations in the considered fragment was not high enough to accurately estimate the ESW, the average ESW of the region was thus considered to estimate the density in these cases.

ESW estimated at the Loky-Manambato regional scale. The "hazard rate" detection function was the best fitting model (using AIC) for the full data set (all forests pooled together) and for most of the forests with more than 40 observations when analyzed separately. This detection function has also been identified as best fitting the data in previous density studies performed in different regions and on other lemur species (Kun-Rodrigues *et al.,* 2014; Quéméré *et al.,* 2010a; Salmona *et al.,* 2013). Surprisingly it was not the best-fitting function in the latest (and only) study on sportive lemur densities conducted in the region (Meyler *et al.,* 2012). This detection function difference is probably due to the amount of data collected and the number of forest fragments surveyed (nine in our study *vs* two in Meyler *et al.,* 2012). The large amount of data analyzed in our study suggests that the hazard rate function might be the one best fitting sportive lemur density data in the Loky-Manambato region and for the *Lepilemur* genera in northern Madagascar (unpublished preliminary data). The density discrepancies between the results from our study and the previous study on *L. milanoii* (Meyler *et al.,* 2012) may mostly be due to the difference in model choice. These discrepancies highlight the importance of (i) being cautious when choosing a model and (ii) of having a large enough data set when choosing a model.

Densities across all forests show high discrepancies, ranging from ~40ind/km² in Ambilondambo, to ~590ind/km² in Ampondrabe. No clear pattern seems to emerge from the comparison between transition/humid (Binara, Antsahabe, Bobankora) and drier forests (all other forest fragments; Fig. 1, Tab. 1) suggesting that a rough forest classification cannot simply explain sportive lemur density in the region. The comparison of forests located on the right (Bekaraoka and Bobankora) and left side (all other forests) of the Manankolana River (Fig. 1, Tab. 1) does not either seem to show any simple pattern explaining the distribution of densities. More complex or refined analyses are required to better understand the probable landscape features driving the density diversity in the region.

In the northern region of Madagascar, the numbers we obtain are not unexpected. For example the Ankarana sportive lemur (*L. ankaranensis*) densities ranges from ~34ind/km² to ~564ind/km² in the Ankarana National Park and Analamerana Special Reserve (Hawkins *et al.,* 1990). Nevertheless, these density results are rather high when compared to the low densities (9.9ind/km²) reported for *L. microdon* in Vohibola in eastern Madagascar (Lehman *et al.,* 2005) or for *L. sahamalazensis* (7-23ind/km²) in the Sahamalaza peninsula, in northwestern Madagascar (Seiler *et al.,* 2013).

The relatively high density observed in the region leads to high population size estimates for the Daraina sportive lemur (Tab. 1). The regional estimate of 52,000 (Tab. 1) is good news when compared, for example, to the population size of 18,000 estimated for the golden crowned sifaka (*Propithecus tattersalli*) which almost shares the same distribution range as the Daraina sportive lemur. Moreover, most forest fragments harbor populations whose sizes are above 1,000, thus comforting us about their potential viability. Nevertheless these numbers show large confidence intervals and should be taken with caution. On the one hand, our estimate does not take into account the forest cover between the Loky and Andrafiamena, an area that was reported to host both Ankarana and Milanoii sportive lemurs (Louis *et al.,* 2006). On the other hand our regional estimate takes into account the regional forest cover (between the Loky and the Manambato River) including small forest fragments that might not be large enough to host sportive lemur populations.

As mentioned in the introduction, sportive lemurs are very easy to hunt diurnally while they are resting in tree holes. Sportive lemurs are part of the bushmeat frequently eaten by locals in other regions (Jenkins *et al.,* 2011), and in some of the visited forest fragments we observed poaching of sportive lemurs (e.g. in Solaniampilana). This potential hunting pressure should be taken seriously, particularly in areas with gold and rock mining activities. Moreover, despite the management of the region by the NGO Fanamby since 2005, forest degradation by logging, mining activities and slash and burn agriculture is still ongoing. Despite the fact that these degradations may occur at lower rates than in unprotected forests (personal observations that would need to be validated) and that the region has suffered lower rates of deforestation than most other regions in the last 50 years (Quéméré *et al.,* 2012), the combined effect of poaching, selective logging and deforestation, could have disastrous middle term effects on the sportive lemur populations. In fact it would be important to determine whether the differences in *Lepilemur* densities observed in Daraina are not due to the history of poaching, since we found no simple environmental correlate. If that was the case, the situation would be more worrying than it seems. It would therefore be important to repeat this kind

of study in this region and extend it over other neighboring regions for comparative purposes, and to identify the effect of environmental degradation, deforestation, and hunting, among other changes.

Preliminary results from this study were used during the International Union for Conservation of Nature (IUCN) Species Survival Commission (SSC) Lemur Red List reassessment meeting in Antananarivo in 2012, to help updating the conservation status of *L. milanoii* from "Data Deficient" to "Endangered" (Schwitzer *et al.,* 2013, 2014). This update and density estimates contrast with the situation of *Microcebus tavaratra* in the Loky-Manambato region (Salmona *et al.,* 2014).

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