Population dynamics of *Lemur catta* at selected sleeping sites in the Tsimanampesotse National Park

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Abstract

Lemur catta is probably the lemur species known best by the public as it is found in many zoological gardens and has featured prominently in movies. Originally very wide-spread in the dry southwestern part of Madagascar, recent reports drew attention to the substantial decrease in suitable habitat due to forest clearing, possibly associated with intensive hunting. Despite this species being prominent at sites where it occurs, information on its population dynamics is only available from a handful of sites covering a very small portion of the species' range that may or may not be representative of its population dynamics in general. This species is known to have marked population changes due to droughts. *Lemur catta* are difficult to survey in the dry spiny thicket, as their distribution seems clumped within large tracts of seemingly unsuitable habitat. Since studies concentrate on sites where the animals occur in sufficient numbers to allow systematic studies, the question arises whether or not the results from these sites can be generalized over the species'range. In order to supplement the existing studies, we initiated a long-term population study of *L. catta* at sleeping sites in Tsimanampesotse National Park, the largest protected area within the range of this species. During the six years of inventories (2013-2018), the number of adults showed little change, but the number of juveniles declined consistently and significantly. The decline was most pronounced during two years with very low rainfall, matching the results of previous studies. If the local meteorological conditions shift towards lower rainfall, the species might be in serious trouble over a large portion of its assumed range that is without permanent watersources as there are basically no forests left where the animals could survive during periods of water and food shortage.

Keywords: *Lemur catta*, Tsimanampesotse National Park, Madagascar, population development

Résumé détaillé

Lemur catta est probablement l'espèce de lémuriens le mieux connue, comme il se trouve dans de nombreux jardins zoologiques et aussi le mieux filmé dans des reportages documentaires. Comme espèce de lémurien très répandue dans la partie Sud-ouest sèche de Madagascar, des rapports récents ont attiré l'attention sur la diminution importante de l'habitat approprié en raison de la destruction de la forêt, éventuellement associée à la chasse intensive. Les informations sur la dynamique de population de cette espèce ne sont disponibles qu'à partir d'une poignée de sites couvrant une très petite partie de sa zone de distribution qui peut être représentative ou non de sa dynamique démographique en général. Les populations ont montré un changement marqué dû à la sécheresse. L'espèce est difficile à inventorier dans l'écosystème forestier épineux, car sa distribution est concentrée dans des vastes étendues d'habitats apparemment inadaptés. Etant donné que les études se concentrent sur les sites où les animaux sont en nombre suffisant pour permettre des études systématiques, la question se pose de savoir si les résultats de ces sites peuvent être généralisés ou non à l'aire de répartition de l'espèce. Afin de compléter les études existantes, nous avons mené une étude sur le suivi à long terme de la population de *L. catta* avec une approche de comptage des animaux par dortoir dans le Parc National de Tsimanampesotse, la plus grande zone protégée où cette espèce est

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largement distribuée. Au cours des cinq années d'inventaire, un faible changement du nombre d'individus adultes a été constaté. Par contre, la diminution du nombre de juvéniles est significatif et de façon constante.

Bien que les fluctuations quotidiennes des individus aient été très importantes, les moyennes mensuelles ont peu varié. Comme les animaux ne sont pas marqués, il est difficile de savoir si les individus se déplacent ou non entre les sites de repos. Le nombre d'adultes a fluctué de façon irrégulière entre les cinq sites de dortoirs. La diminution du nombre d'individus a été bien constatée au cours de deux ans pendant lesquelles la précipitation dans la région est très faible.

Le nombre de juvéniles a nettement diminué au cours des deux années avec peu de pluie (2016 et 2017). Surtout en 2016, les animaux semblaient être en très mauvaise condition physique. Si les conditions ambiantes s'aggravent, l'espèce pourrait avoir de graves problèmes sur une grande partie de sa zone de distribution supposée sans eau permanente, car il n'y a pratiquement pas de forêt galerie où les animaux pourraient survivre pendant les temps de pénurie d'eau et de nourriture.

Mots clés : *Lemur catta*, Parc National de Tsimanampesotse, dynamique de la population.

Introduction

Recent reports have drawn attention to a substantial decline of *Lemur catta* over its range (Gould & Sauther, 2016; LaFleur *et al*., 2016). These reports have been debated due to methodological questions and the unreliability of surveys based on just a few days of inventory (Murphy *et al*., 2017). The debate seems futile as it is clear that the extent of suitable habitat for the species has declined substantially, thus justifying the assumption of a substantial reduction of the species' population size and its categorization as being "Endangered" (Goodman *et al*., 2006; Brinkmann *et al*., 2014; Schwitzer *et al*., 2014; Waeber *et al*., 2015). While the destruction of the dry spiny thicket can be measured precisely, population estimates of *L. catta* are difficult to compile within the vegetation formations of southern Madagascar as the vegetation can be very patchy, sometimes difficult to access, and the species can make extensive use of terrestrial travel and rocky habitats (Goodman & Langrand, 1996; Cameron & Gould, 2013; Gabriel, 2013; Gould & Gabriel, 2014). In addition, populations undergo substantial fluctuations due to droughts and associated food and water shortage (Gould *et al*., 1999, 2003; Jolly *et al*., 2002, 2006).

For the present study we compiled information on a portion of the population of *L. catta* in Tsimanampesotse National Park. This park represents the largest protected area of southwestern Madagascar and thus a potential stronghold for biodiversity conservation. Yet, pressure of hunting and collection is high for all species that can be used or marketed (Walker & Rafeliarisoa, 2012; Sauther *et al*., 2013; Andriamparany *et al*., 2015; Ganzhorn *et al*., 2015; Randriamiharisoa *et al*., 2015; LaFleur *et al*., 2016; Manjoazy *et al*., 2017; Goodman *et al*., 2018). Here, we counted *L. catta* at five sleeping sites around the cave of Mitoho at the western edge of Tsimanampesotse National Park between 2013 and 2018 (Figure 1). Specific objectives of our study were: 1) to add baseline information for this species as part of the management plan for this protected area (Madagascar National Parks, 2013); 2) to provide baseline data for future estimates on the population development of *L. catta* at a selected site within Tsimanampesotse National Park; 3) to scrutinize whether or not counts at five sleeping sites can provide insight into conclusions about population dynamics as compared to spatially more extensive surveys.

Methods

Study site

Tsimanampesotse National Park covers about 230 km² and is located in southwestern Madagascar (24°03'-24°12'S, 43°46'-43°50'E), 85 km south of Toliara. The study was carried out at the western escarpment of the limestone Mahafaly Plateau between the Andranovao camp (24°01.578'S, 43°44.238'E) and the Grotte de Mitoho (24°02.973'S, 43°45.095'E), 40 to 115 m above sea level. The vegetation of the study region is xerophytic starting at the coastal plain with formations resting on sand and thin reddish clays, followed by an area at approximately 50 m above sea level near the foot of the Mahafaly Plateau, dominated by sparse vegetation in close vicinity to the soda lake (Tsimanampesotse Lake), and dry spiny thicket on the limestone Mahafaly Plateau. Trees on limestone are distinctly smaller and occur in much lower densities, resulting in reduced vegetation cover and biomass production compared to the littoral forest. More details of the study site are provided by Goodman *et al*. (2002, 2018), Andriatsimietry *et al*. (2009), Hammer & Ramilijaona (2009), Rakotondranary *et*

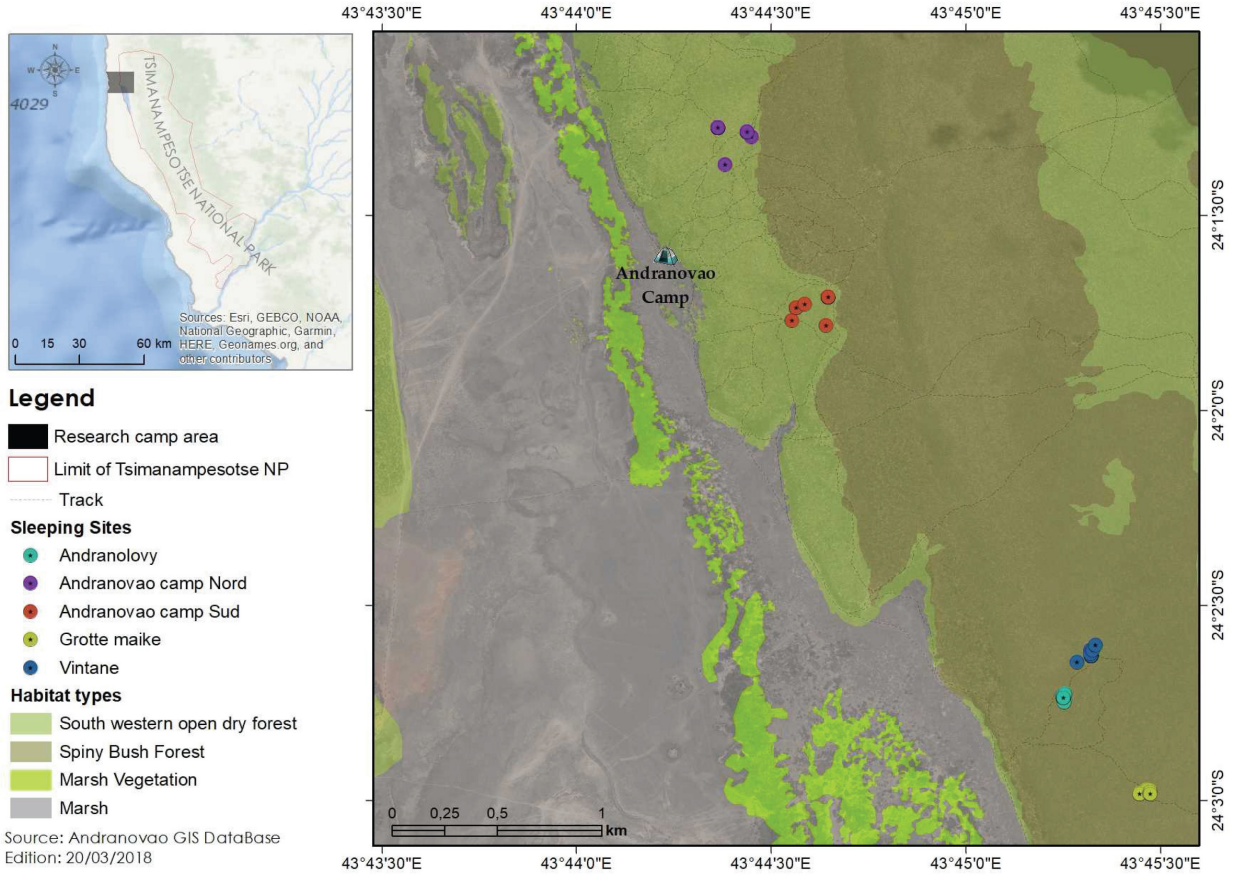

Figure 1. Location of the study site and sleeping sites of *Lemur catta*. The small black square in the left-hand figure, representing the northwest corner of the Tsimanampesotse National Park, is enlarged in the right-hand figure.

al. (2010), Rasoma *et al*. (2010), Bohr *et al*. (2011), Ratovonamana *et al*. (2011, 2013), Sauther *et al*. (2013), and LaFleur *et al*. (2014).

Rainfall in the southwestern region of Madagascar is highly seasonal and rarely exceeds 400 mm per year, most rains falling between December and February (Donque, 1975; Ratovonamana *et al*., 2011). Rainfall measured with conventional methods is supplemented by dew though the effect of dew is poorly understood (Hanisch *et al*., 2015). As a general classification, the year is divided in a wet season from December to April and a dry season from May to November, even though several years can pass without any measurable or significant rainfall or rainfall pattern can shift towards the season previously considered the dry season. The region experiences considerable variation in daily mean temperatures, ranging between 17 and 34°C (Ratovonamana *et al*., 2013). The exceptional spatial and temporal variation of weather conditions in the region makes conclusions on climate trends difficult when based on physical measurements. However, extrapolating climate models postulate the temperature to have increased over the last few decades. According to the models, precipitation also is supposed to have increased, though the latter is not supported by the perception of people living in the region (Hannah *et al*., 2008; Stalenberg *et al*., 2018).

During the study period, rainfall was measured at the Andranovao camp with rain gauges. Temperature was measured with ibuttons (Hydrochron IButton, Dallas Semiconducter, USA) installed under the shade of the tree some 1.5 m above the ground. Each I-button was programmed to take temperature and relative hat the same site since 2006. In 2011, the collection of climate data was reinforced by the installation of a HOBO micro station, with 04 automatic sensors, to collect other climate variables.

Subterranean water surfaces occur at the western edge of the Mahafaly Plateau either at the foot of the plateau or accessed in caves. At these sites, some trees (such as *Ficus* spp. or *Tamarindus indica*) can reach substantial dimensions and are used as sleeping sites by *Lemur catta* (Rasoloariniaina *et al*., 2016).

Population monitoring

Initially, we used several kilometers of transects originally installed to monitor tortoises (*Astrochelys*

radiata and Pyxis arachnoides) in Tsimanampesotse National Park (Hammer & Ramilijaona, 2009; Rasoma *et al*., 2010) and to survey *Lemur catta* as part of the conservation and monitoring objectives of Madagascar National Park (Madagascar National Parks, 2012, 2013). Sightings were infrequent and could not be used for population monitoring. Combining transects at sites known to be used by *L*. *catta* with transects at sites obviously not used by the animals seemed arbitrary as any result could have been obtained simply by different placements of transects. We therefore decided to count animals at known sleeping sites. Due to the rugged terrain, only sleeping sites in trees were considered though this species also spends nights on cliffs and in caves (Sauther *et al*., 2013). Five sleeping sites were identified within 4 km of the Andranovao research station (Figure 1). These were Andranovao Camp Nord, Andranovao Camp Sud, Vintane, Andranolovy, and Grotte maike. Geographic coordinates of the sites are listed in Appendix 1. Each sleeping site was visited early in the morning (arriving prior to sunrise) or just prior to sunset (leaving after sunset). Animals were counted when daylight allowed an overview over the group spread and numbers of individuals. Animals were counted at irregular intervals over the years (Appendix 1). We distinguished between adult males and females and juvenile males and females. The counting of animals took around 30 mn per sleeping site. Data were analyzed with IBM SPSS 25.

Results

Ambient conditions

Rainfall patterns are shown for the years 2012 to 2018 (Figure 2). Even though lemur counts started only in 2013, rainfall data for 2012 were included as lemur populations might respond to ambient conditions with a lag phase. The study region experienced a drought in 2012 with only 11 days of intermittent rain and an annual rainfall of less than 80 mm (Figure 2). Between 2013 and 2015 annual rainfall approached the long-term mean but dropped again to only 97.5 mm and 98 mm in 2016 and 2017, respectively.

Population dynamics

Between November 2013 and November 2018,107 counts were completed at the five sleeping sites (Appendix 1). Counts at sleeping sites yielded between 1 and 31 individuals during the 81 survey days. While day-to-day fluctuations were very high, monthly means varied little. Since animals were not marked, we do not know whether or not individuals moved between sleeping sites. The number of adults seemed to fluctuate inconsistently between the five sleeping sites. Except for the Andranolovy site, the number of juveniles dropped consistently between 2013 and 2017. When all data were pooled for the five sites, there was no consistent trend of the number of juveniles or adults over the six years of survey (Spearman correlation: juveniles: r_s = - 0.77, P = 0.07, n = 6;adults: r_s = - 0.27, P = 0.61, n = 6; Figure 3). On the temporal scale analyzed here, annual rainfall was related significantly to the number of juveniles (r_s = 0.83, P = 0.04, n = 6) but not to the numbers of adults (r_s = 0.387, P = 0.61, n = 6). The number of juveniles dropped markedly in the two years with little rain (2016 and 2017). Especially in 2016, the animals appeared to be in very poor body condition (Figure 4). The low amount of rain in 2012 did not seem to be reflected in the number of juveniles recorded in 2013.

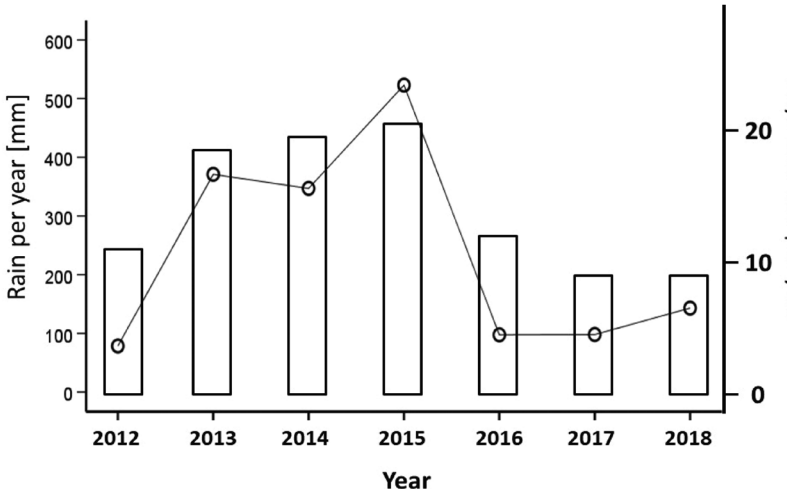

Figure 2. Rainfall measured at Andranovao camp between 2012 and 2018. Bars represent days with rain. The line indicates total annual rainfall.

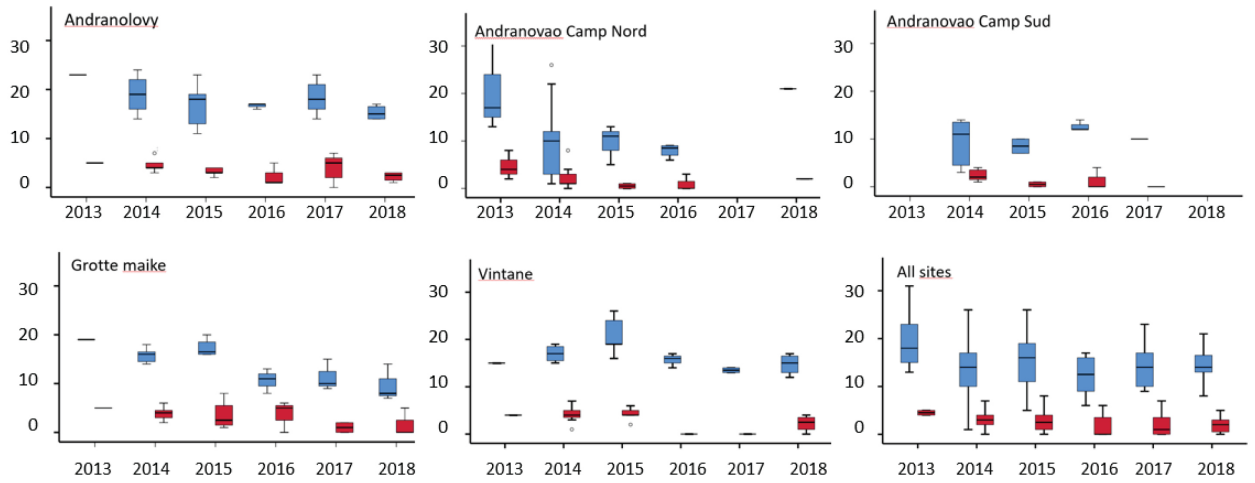

Figure 3. Total number of individuals (adults and juveniles; grey bars) counted at sleeping sites around the Andranovao camp and the Grotte de Mitoho in Tsimanampesotse between 2013 and 2018. Values for total counts are medians, quartiles, and ranges. Values for juveniles are shown separately (hatched bars). The circles mark outliers according to the data classification of SPSS. Note that no surveys were carried out at Andranovao Sud Camp in 2013 and in 2018, and at Andranovao Camp Nord in 2017.

Figure 4. *Lemur catta* in very poor condition probably due to the lack of food during the drought of 2016 (according to the scoring system by Berg *et al*. 2009; Millette *et al*. 2015). Photo taken in September 2016. (Photo by Yedidya Ratovonamana.)

Discussion

With the data at hand, at least parts of Tsimanampesotse National Park, together with yet unpublished data by M. LaFleur from the same area, can provide an additional site to understand population trends of *Lemur catta*; the other sites being Berenty, Bezà Mahafaly, Anja, and Tsaranoro. For the time being, the Tsimanampesotse data should only be considered a snapshot as “long-term” studies are considered to cover at least 10 years of data collection (Kappeler *et al*., 2017) and the southwestern part of Madagascar is characterized by recurrent droughts affecting humans and lemurs alike, making even 10 years of data collection look like a point in time

(Gould *et al*., 1999, 2003; Richard *et al*., 2000; Jolly *et al*., 2002, 2006; Ratovonamana *et al*., 2011). The challenge is to separate short-term effects of ambient conditions from long-term population trends. Long-term effects of the environmental conditions are poorly documented. The increase in ambient temperature by more than 1°C is likely to have negative effects (Hannah *et al*., 2008; Brown & Yoder, 2015). Though temperature changes will have major effects, increased unpredictability might even be of more concern and act more rapidly (Ganzhorn, 1995; Wright, 1999; Dewar & Richard, 2007). In addition, the unpredictable precipitation pattern seems to have shifted with rains falling later in the calendar year in southwestern Madagascar (Ratovonamana *et al*., 2013). Though *L*. *catta* exhibit substantial behavioral flexibility as illustrated by their responses to severe ambient conditions, weather unpredictability is certainly a problem, especially if reproduction would mainly be triggered by photoperiod (Pereira, 1993; Kelley, 2013; Gould *et al*., 2015).

For a semi-terrestrial species such as *L*. *catta*, that has no problem utilizing anthropogenic landscapes, human encroachment could be mitigated easily by strengthening conservation measures, thus countering fragmentation effects, such as establishing or maintaining hedges or groves with trees that could be used by animals and people (Gardner *et al*., 2009, 2013; Sauther & Cuozzo, 2009; Irwin *et al*., 2010; Cameron & Gould, 2013; Andriamparany *et al*., 2015; Antsonantenainarivony, 2015; Gérard *et al*., 2015; Gould & Andrianomena, 2015; Goetter *et al*., 2017; Nopper *et al*., 2017; Steffens *et al*., 2017). Yet, while these technical solutions are at hand, the actual problems on the ground (economic perspectives, conservation issues) are not addressed to the extent needed to make a difference. Any attempt to solve the problems is outrun by excessive human population growth, poor governance and aid, and conservation projects that pay too little attention to local peculiarities (Freudenberger, 2010; Richard & Ratsirarson, 2013; Waeber *et al*., 2016; Neudert *et al*., 2017).

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Appendix 1. Counts of *Lemur catta* at five sleeping sites in Tsimanampesotse National Park between 2013 and 2018.

Sleeping site	Date	Latitude	Longitude	Sleeping tree	Male	Female	Juvenile	Total
Andranolovy	25/11/2013	24.045650	43.754200	*Tamarindus indica*	6	12	5	23
Andranovao camp Nord	07/11/2013	24.021250	43.739433	*Delonix floribunda*	6	17	8	31
Andranovao camp Nord	08/11/2013	24.021250	43.739433	*Delonix floribunda*	4	11	2	17
Andranovao camp Nord	08/11/2013	24.021250	43.739433	*Delonix floribunda*	4	5	4	13
Vintane	24/11/2013	24.043833	43.755400	*Ficus* sp.	4	7	4	15
Grotte maike	26/11/2013	24.049583	43.757783	*Tamarindus indica*	5	9	5	19
Andranolovy	21/02/2014	24.045650	43.754200	*Tamarindus indica*	3	4	7	14
Andranovao camp Nord	25/02/2014	24.021650	43.740850	*Delonix floribunda*	1	1	1	3
Andranovao camp Nord	26/02/2014	24.021250	43.739433	*Delonix floribunda*	1	1	1	3
Andranovao camp Sud	28/02/2014	24.028483	43.744150	*Commiphora marchandii*	0	1	2	3
Grotte maike	23/02/2014	24.049583	43.757783	*Tamarindus indica*	6	7	3	16
Vintane	22/02/2014	24.043833	43.755400	*Ficus* sp.	6	5	4	15
Andranolovy	24/03/2014	24.045650	43.754200	*Tamarindus indica*	4	10	4	18
Andranovao camp Nord	07/03/2014	24.021433	43.740667	*Boscia longifolia*	1	0	0	1
Andranovao camp Nord	07/03/2014	24.021250	43.739433	*Delonix floribunda*	1	0	0	1
Andranovao camp Nord	08/03/2014	24.021250	43.739433	*Delonix floribunda*	3	4	3	10
Andranovao camp Sud	08/03/2014	24.028483	43.744150	*Commiphora marchandii*	3	4	3	10
Andranovao camp Sud	12/03/2014	24.029717	43.744050	*Delonix floribunda*	3	5	4	12
Grotte maike	25/03/2014	24.049583	43.757783	*Tamarindus indica*	4	7	4	15
Vintane	25/03/2014	24.043833	43.755400	*Ficus* sp.	3	9	4	16
Andranovao camp Nord	07/04/2014	24.021250	43.739433	*Delonix floribunda*	2	3	3	8
Andranovao camp Nord	09/04/2014	24.021433	43.740667	*Boscia longifolia*	3	12	2	17
Andranovao camp Nord	24/04/2014	24.021250	43.739433	*Delonix floribunda*	10	13	3	26
Andranovao camp Sud	08/04/2014	24.028483	43.744150	*Commiphora marchandii*	4	6	4	14
Grotte maike	26/04/2014	24.049583	43.757783	*Tamarindus indica*	4	7	3	14
Vintane	25/04/2014	24.043833	43.755400	*Ficus* sp.	8	8	3	19
Andranolovy	25/05/2014	24.045650	43.754200	*Tamarindus indica*	6	12	4	22
Grotte maike	24/05/2014	24.049583	43.757783	*Tamarindus indica*	5	10	2	17
Vintane	25/05/2014	24.043833	43.755400	*Ficus* sp.	6	8	4	18
Andranolovy	24/09/2014	24.045650	43.754200	*Tamarindus indica*	6	10	4	20
Andranovao camp Nord	04/09/2014	24.021250	43.739433	*Delonix floribunda*	4	5	1	10
Andranovao camp Nord	05/09/2014	24.021433	43.740667	*Boscia longifolia*	3	4	1	8
Andranovao camp Sud	05/09/2014	24.028483	43.744150	*Commiphora marchandii*	1	1	1	3
Andranovao camp Sud	06/09/2014	24.028940	43.742780	*Didierea madagascariensis*	4	8	2	14
Grotte maike	25/09/2014	24.049583	43.757783	*Tamarindus indica*	5	7	4	16
Vintane	25/09/2014	24.043833	43.755400	*Ficus* sp.	4	10	1	15
Andranolovy	24/10/2014	24.045650	43.754200	*Tamarindus indica*	7	12	5	24
Andranovao camp Nord	07/10/2014	24.021250	43.739433	*Delonix floribunda*	4	5	1	10
Andranovao camp Sud	08/10/2014	24.028483	43.744150	*Commiphora marchandii*	5	6	2	13
Grotte maike	25/10/2014	24.049583	43.757783	*Tamarindus indica*	4	8	6	18
Vintane	24/10/2014	24.043833	43.755400	*Ficus* sp.	4	7	6	17
Andranolovy	24/11/2014	24.045650	43.754200	*Tamarindus indica*	5	8	3	16
Andranovao camp Nord	07/11/2014	24.021250	43.739433	*Delonix floribunda*	4	4	4	12
Andranovao camp Nord	08/11/2014	24.021433	43.740667	*Boscia longifolia*	6	8	8	22
Andranovao camp Sud	08/11/2014	24.028483	43.744150	*Commiphora marchandii*	2	3	1	6
Grotte maike	25/11/2014	24.049583	43.757783	*Tamarindus indica*	2	7	5	14
Vintane	25/11/2014	24.043833	43.755400	*Ficus* sp.	5	7	7	19
Andranolovy	25/03/2015	24.045650	43.754200	*Tamarindus indica*	10	10	3	23
Grotte maike	25/03/2015	24.049583	43.757783	*Tamarindus indica*	4	10	2	16
Vintane	24/03/2015	24.043833	43.755400	*Ficus* sp.	6	6	4	16

Sleeping site	Date	Latitude	Longitude	Sleeping tree	Male	Female	Juvenile	Total
Andranolovy	25/04/2015	24.045650	43.754200	*Tamarindus indica*	7	8	4	19
Andranovao camp Nord	07/04/2015	24.021250	43.739433	*Delonix floribunda*	5	6	0	11
Andranovao camp Nord	08/04/2015	24.021433	43.740667	*Boscia longifolia*	4	6	1	11
Andranovao camp Sud	07/04/2015	24.028483	43.744150	*Commiphora marchandii*	3	3	1	7
Vintane	24/04/2015	24.043833	43.755400	*Ficus* sp.	7	10	2	19
Andranolovy	24/05/2015	24.045650	43.754200	*Tamarindus indica*	6	5	2	13
Andranovao camp Nord	07/05/2015	24.021250	43.739433	*Delonix floribunda*	2	2	1	5
Andranovao camp Sud	07/05/2015	24.028483	43.744150	*Commiphora marchandii*	4	6	0	10
Grotte maike	25/05/2015	24.049583	43.757783	*Tamarindus indica*	7	9	1	17
Vintane	25/05/2015	24.043833	43.755400	*Ficus* sp.	7	8	4	19
Andranolovy	24/09/2015	24.045650	43.754200	*Tamarindus indica*	4	10	4	18
Andranovao camp Nord	07/09/2015	24.021250	43.739433	*Delonix floribunda*	4	9	0	13
Grotte maike	25/09/2015	24.049583	43.757783	*Tamarindus indica*	4	9	3	16
Vintane	25/09/2015	24.043833	43.755400	*Ficus* sp.	6	13	5	24
Andranolovy	25/10/2015	24.045650	43.754200	*Tamarindus indica*	4	4	3	11
Grotte maike	26/10/2015	24.049583	43.757783	*Tamarindus indica*	4	8	8	20
Vintane	26/10/2015	24.043833	43.755400	*Ficus* sp.	6	14	6	26
Andranovao camp Nord	07/04/2016	24.021250	43.739433	*Delonix floribunda*	3	6	0	9
Andranolovy	28/09/2016	24.045590	43.754190	*Tamarindus indica*	7	9	1	16
Andranovao camp Nord	06/09/2016	24.021250	43.739433	*Delonix floribunda*	4	5	0	9
Andranovao camp Nord	08/09/2016	24.021433	43.740667	*Boscia longifolia*	4	4	0	8
Andranovao camp Sud	07/09/2016	24.028483	43.744150	*Commiphora marchandii*	5	7	0	12
Grotte maike	29/09/2016	24.049650	43.757860	*Tamarindus indica*	4	4	0	8
Andranolovy	28/10/2016	24.045610	43.754220	*Tamarindus indica*	7	10	1	17
Andranovao camp Sud	04/10/2016	24.029500	43.742580	*Delonix floribunda*	4	8	0	12
Grotte maike	28/10/2016	24.049620	43.757940	*Tamarindus indica*	4	7	6	11
Andranolovy	27/11/2016	24.045800	43.754240	*Salvadora angustifolia*	7	10	5	17
Andranovao camp Nord	04/11/2016	24.022820	43.739720	*Boscia longifolia*	2	4	3	6
Andranovao camp Sud	03/11/2016	24.028940	43.742780	*Didierea madagascariensis*	4	10	4	14
Grotte maike	28/11/2016	24.049660	43.757880	*Tamarindus indica*	4	9	5	13
Vintane	27/09/2016	24.043590	43.755360	*Ficus* sp.	6	8	0	14
Vintane	27/10/2016	24.043730	43.755370	*Ficus* sp.	7	9	0	16
Vintane	27/11/2016	24.044100	43.754800	*Albizia mahalao*	6	11	0	17
Andranolovy	25/04/2017	24.045570	43.754190	*Tamarindus indica*	6	8	2	14
Andranovao camp Sud	06/04/2017	24.028800	43.743130	*Didierea madagascariensis*	4	6	0	10
Grotte maike	25/04/2017	24.049740	43.757470	*Tamarindus indica*	4	5	0	9
Vintane	24/04/2017	24.043590	43.755460	*Ficus* sp.	6	7	0	13
Andranolovy	25/09/2017	24.045460	43.754270	*Tamarindus indica*	6	10	0	16
Grotte maike	26/09/2017	24.049690	43.757890	*Tamarindus indica*	6	4	0	10
Vintane	06/09/2017	24.043376	43.755580	*Ficus* sp.	6	8	0	14
Andranolovy	24/10/2017	24.045610	43.754200	*Tamarindus indica*	6	9	6	21
Andranolovy	26/10/2017	24.045590	43.754200	*Ficus* sp.	7	9	7	23
Grotte maike	25/10/2017	24.049640	43.757920	*Tamarindus indica*	5	8	2	15
Andranolovy	24/11/2017	24.045630	43.754220	*Tamarindus indica*	5	8	5	18
Grotte maike	24/11/2017	24.049740	43.757930	*Tamarindus indica*	2	6	2	10
Vintane	24/03/2018	24.043820	43.755370	*Ficus* sp.	4	6	2	12
Grotte maike	24/03/2018	24.049730	43.757920	*Tamarindus indica*	2	6	0	8
Andranolovy	25/03/2018	24.045510	43.754170	*Tamarindus indica*	7	8	2	17
Grotte maike	24/04/2018	24.049680	43.757870	*Tamarindus indica*	1	6	0	7
Vintane	25/04/2018	24.043650	43.755460	*Ficus* sp.	5	9	3	17
Andranolovy	25/04/2018	24.045720	43.754140	*Tamarindus indica*	6	7	3	16
Vintane	24/05/2018	24.043870	43.755420	*Ficus* sp.	6	8	0	14
Andranolovy	25/05/2018	24.045630	43.754220	*Tamarindus indica*	4	9	1	14

Sleeping site	Date	Latitude	Longitude	Sleeping tree	Male	Female	Juvenile	Total
Andranovao	08/05/2018	24.029560	43.742420	*Delonix floribunda*	6	13	2	21
Andranolovy	24/11/2018	24.045650	43.754140	*Ficus* sp.	4	7	3	14
Vintane	25/11/2018	24.043740	43.755230	*Ficus* sp.	5	7	4	16
Grotte maike	25/11/2018	24.049750	43.758030	*Tamarindus indica*	3	6	5	14