Chapter 15. Lemurs of the Beanka Forest, Melaky Region, western Madagascar

Melanie Dammhahn[1,2], Matthias Markolf[1], Mia-Lana Lührs[3], Urs Thalmann[4,5] & Peter M. Kappeler[1,3]
[1]Behavioral Ecology & Sociobiology Unit, German Primate Center (DPZ), Leibniz Institute for Primate Research, Kellnerweg 4, D-37077 Göttingen, Germany
E-mail: mdammha@gwdg.de, mmarkol@gwdg.de, pkappel@gwdg.de
[2]Present address: Groupe de recherche en écologie comportementale et animale, Département des Sciences Biologiques, Université du Québec à Montréal, Case postale 8888, succursale centre-ville, Montréal, Québec, Canada, H3C 3P8
[3]Department of Sociobiology/Anthropology, Johann-Friedrich-Blumenbach Institute of Zoology & Anthropology, University of Göttingen, Kellnerweg 6, D-37077 Göttingen, Germany
E-mail: mluehrs@gwdg.de
[4]Anthropological Institute, University of Zurich, Winterthurerstrasse 190, 8057 Zürich, Switzerland
[5]bt biofor GmbH, Hardturmstrasse 269/4, 8005 Zürich, Switzerland
E-mail: urs.thalmann@bt-biofor.ch

Abstract

Explaining the biodiversity and, in particular, the high levels of microendemism of primates in Madagascar has been a scientific challenge for many decades. A prerequisite to our understanding of lemur biogeography is high-resolution spatial data based on homogenous sampling effort across the island. Although the distribution of lemurs is comparatively well documented, some areas of Madagascar have been poorly surveyed. Among these zones is the large zone of microendemism between the Tsiribihina and the Betsiboka Rivers in western Madagascar. Here, we add new data on the distribution of several less known lemur species in this area. Two rapid lemur surveys in combination with hitherto unpublished information confirms the presence of at least 11 primate species from all five lemur families in the Beanka Forest - an isolated fragment of dry deciduous forest on limestone close to Maintirano. This level of species diversity is considerable and exceeds most other dry deciduous forests on the island. The specific determinations of *Cheirogaleus* sp. indet., *Lepilemur* cf. *randrianasoli*, *Hapalemur* cf. *griseus ranomafanensis*, and *Mirza* sp. in the Beanka Forest need to be supported by morphological and genetic data. Overall, lemur distribution in the surveyed zone of microendemism only partly supports the centers-of-endemism hypothesis. Given its extraordinarily high lemur diversity, the Beanka Forest deserves more attention from researchers studying lemur ecology and behavior. Current programs of Biodiversity Conservation Madagascar are important for the conservation of this forest area.

Key words: conservation, lemur survey, microendemism, primates, species distribution, *tsingy* forest

Résumé détaillé

Depuis de nombreuses décennies, l'explication de la biodiversité et, en particulier, des niveaux élevés de micro-endémisme parmi les primates à Madagascar a été un défi scientifique. Les données spatiales à haute résolution, basées sur un effort d'échantillonnage homogène sur toute l'île, sont une condition nécessaire à une meilleure compréhension de la biogéographie des lémuriens. Bien que la répartition des lémuriens soit relativement bien documentée, certaines régions de Madagascar ont été mal étudiées, y compris la grande zone de micro-endémisme qui s'étend entre les fleuves Tsiribihina et Betsiboka dans l'Ouest de l'île. Cette étude ajoute de nouvelles données sur la répartition de plusieurs espèces de lémuriens moins connues dans cette région de micro-endémisme. La combinaison de deux inventaires rapides de lémuriens avec des informations non publiées confirment la présence de 11 espèces de primates appartenant aux cinq familles de lémuriens dans la Forêt de Beanka, un fragment isolé de forêt sèche sur calcaires près de Maintirano. Cette diversité des espèces est remarquable et dépasse celle de la plupart des autres forêts sèches à Madagascar. Les déterminations des espèces *Cheirogaleus* sp. indet., *Lepilemur* cf. *randrianasoli*, *Hapalemur* cf. *griseus ranomafanensis* et *Mirza* sp. dans la forêt de Beanka demanderont à être confirmées par des données morphologiques et génétiques. En résumé, la répartition des lémuriens dans cette zone de micro-endémisme ne supporte que partiellement l'hypothèse des centres

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d'endémisme. Compte tenu de sa diversité en lémuriens extraordinairement élevée et des menaces qui pèsent sur sa conservation, la forêt de Beanka mérite plus d'attention scientifique de la part des chercheurs qui étudient l'écologie et le comportement des lémuriens. En outre, des mesures immédiates doivent être prises pour conserver cette forêt à haute diversité.

Mots clés : conservation, inventaires rapides de lémuriens, micro-endémisme, primates, distribution des espèces, forêt sur *tsingy*

Introduction

Explaining the extraordinarily high biodiversity of Madagascar - one of the world's biodiversity hotspots (Myers *et al.*, 2000) - has been a fascinating scientific challenge for many decades. High levels of regional microendemism are the principal aspect of the island's biodiversity. Several hypotheses have been developed to explain this pattern (recently summarized in Vences *et al.*, 2009). Traditionally, it has been proposed that adaptations to differences between the humid eastern and the dryer western portions of the island have resulted in different vertebrate communities (Petter *et al.*, 1977; Tattersall, 1982; Richard & Dewar, 1991). Further, major rivers have been cited to act as barriers separating different zones of microendemism within these phytogeographic regions (Martin, 1972; Pastorini *et al.*, 2003; Goodman & Ganzhorn, 2004). Recently, it has been hypothesized that patterns of regional endemism are caused by the distributional shifts of species associated with Quaternary habitat alterations (Wilmé *et al.*, 2006). During re-current dry periods in the Quaternary, river systems with high elevation sources served as refuges and centers of subsequent dispersion, whereas river catchments with low elevation sources were isolated for periods allowing local allopatric speciation. A prerequisite to test contrasting predictions of these hypotheses, and, thus, to ultimately understand the evolution of Madagascar's living biodiversity, is high-resolution spatial data based on relatively homogenous sampling across the island.

Traditionally, Malagasy primates have been widely used as a suitable taxonomic group to study patterns of microendemism. They are relatively species-rich with currently over 100 recognized taxa (Mittermeier *et al.*, 2010) and have received much scientific attention during the last decades. For example, several well-sampled genera of lemurs (*Eulemur*, *Microcebus*, *Propithecus*) served as empirical examples for the centers-of-endemism hypothesis (Wilmé *et al.*, 2006) and species' spatial distribution follow the predicted patterns of microendemism (see also Goodman & Ganzhorn, 2004). Although the spatial distribution of lemurs is comparatively well documented, some areas of Madagascar have not been adequately surveyed. Since detailed knowledge of distribution ranges, as well as a well-supported taxonomy, are critical to test predictions of the various biogeograpical hypotheses outlined above, further field research effort needs to be made in order to fill in needed information on lemur distribution. Therefore, the main aim of this current study was to contribute inventory data on lemur species presence in a previously less studied region of western Madagascar.

One of the largest microendemism areas in western Madagascar is the zone north of the Tsiribihina and south of the Betsiboka Rivers covering 77,259 km² (ca. 13% of Madagascar's land surface) (Wilmé *et al.*, 2006). Only 11.3% of this biogeographical region is still covered by forest, which is lower than the national average of 18.3%, and the Bemaraha reserve complex mainly represents this area. The remaining forests are highly fragmented and distributed over a matrix of secondary savanna. Up to date, only 4% of this region is legally protected (protected areas: Tsingy du Bemaraha National Park and Strict Nature Reserve, Tsingy de Namoroka National Park, Baie de Baly National Park, Special Reserves of Bemarivo, Kasijy, and Maningoza) (Wilmé *et al.*, 2006). Although homogeneous distribution of biodiversity in the forest fragments in this region would provide an interesting test case of the microendemism hypothesis, this region is among the least sampled in western Madagascar and has received comparatively little scientific attention.

Here, we summarize field inventory data collected on the lemur community of the Beanka Forest – a ca. 17,100 ha forest block in the Maintirano region (Figure 15-1). This forest is an isolated fragment of dry and semi-deciduous forest on limestone (*tsingy*) (see Chatelain *et al.*, 2013; Rakotozafy *et al.*, 2013), ca. 100 km north of the Tsingy du Bemaraha National Park and Strict Nature Reserve. Hitherto, no lemur inventory of this region is available and the remaining small fragments of dry deciduous forest in the Maintirano region are not protected. Thus, the specific aims of this study were: (1) to summarize data collected during rapid lemur surveys, as well as published and unpublished information on the lemur

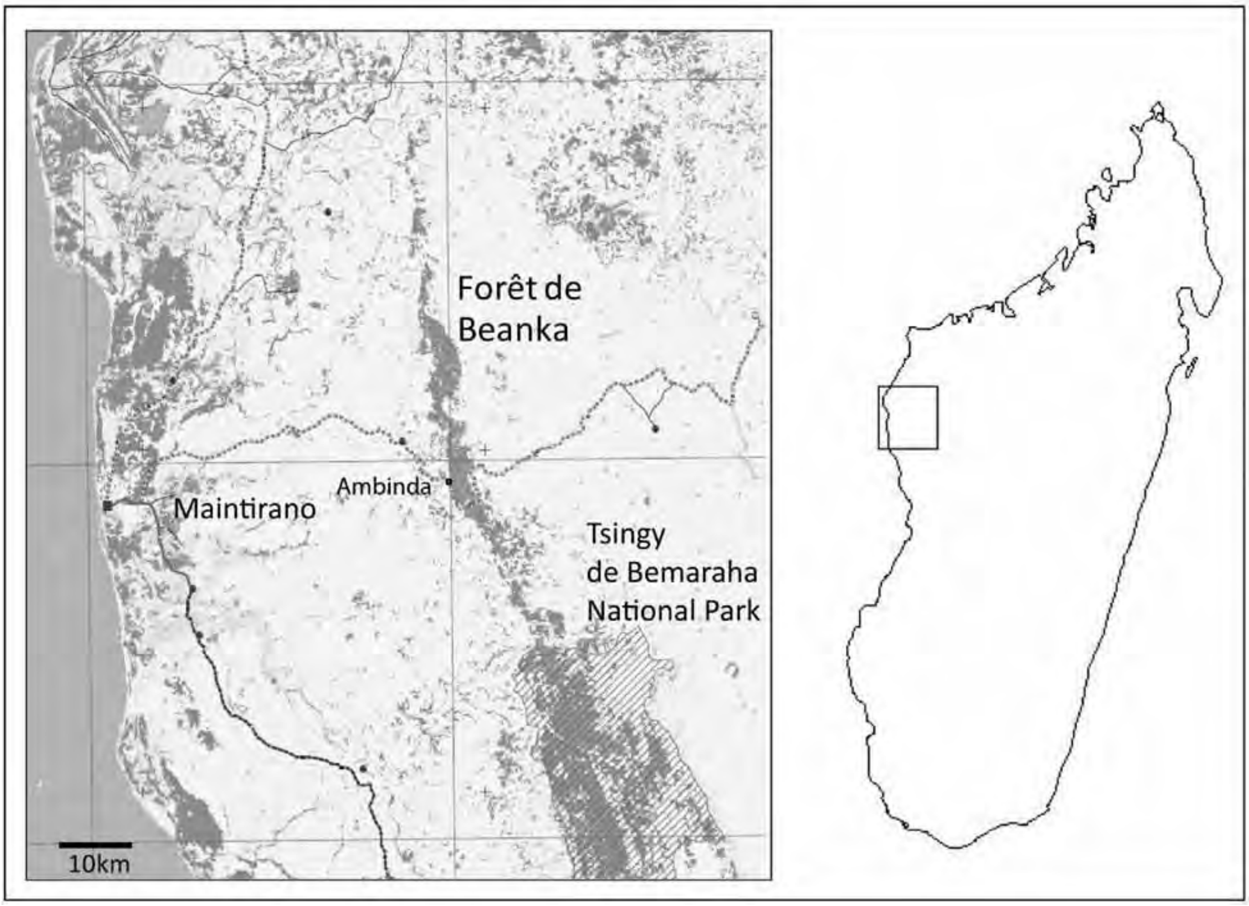

Figure 9-1. Map of the Beanka Forest, Melaky Region, western Madagascar (based on Madagascar Vegetation Mapping Project, www.vegmad.org).

community of the Beanka Forest and (2) to document potential threats for the conservation of lemurs in this isolated block of dry deciduous forest.

Within the last decades the species diversity of lemurs has increased to over 100 recognized taxa (Mittermeier *et al*., 2010), partly due to increased taxonomic interest, utilization of molecular methods, renewed field efforts, and the application of the Phylogenetic Species Concept (Cracraft, 1983; Groves, 2001), as compared to the traditional Biological Species Concept (Mayr, 1963) (Tattersall, 2007). In particular, many new species of nocturnal lemurs have been described for the genera *Avahi* (Thalmann & Geissmann, 2005; Zaramody *et al*., 2006; Andriantompohavana *et al*., 2007; Lei *et al*., 2008), *Lepilemur* (Andriaholinirina *et al*., 2006; Louis *et al*., 2006a; Craul *et al*., 2007), *Mirza* (Kappeler *et al*., 2005), and *Microcebus* (Rasoloarison *et al*., 2000; Kappeler *et al*., 2005; Louis *et al*., 2006b; Olivieri *et al*., 2007; Radespiel *et al*., 2008, 2012). Due to a lack of information on exact geographic distribution, abundance, ecology, and behavior for the majority of these newly recognized species, their IUCN “Red List” conservation status is difficult to assess, although some are most likely restricted to small areas of fragmented forest. Therefore, a further specific aim of this study was to contribute additional field data on taxa falling in this group, notably *Microcebus myoxinus*, *Mirza coquereli*, *Lepilemur randrianasoli*, and *Avahi cleesei* to help clarifying species distribution patterns.

Herein, we use the taxonomy based on the Phylogenetic Species Concept (as presented in Mittermeier *et al.*, 2010). It is important to consider this in evaluating distribution of lemur taxa and the literature. For example, Goodman & Ganzhorn (2004), Ganzhorn *et al.* (2006), and Wilmé *et al.* (2006) used the “traditional” Biological Species Concept approach for their biogeographic analyses.

Methods

We conducted a rapid lemur survey between 30 July and 2 August 2010 and complemented it with data from a day and night survey in March 2010 (March 18 and 19, respectively) in the Beanka Forest, in close vicinity of the village of Ambinda, ca. 60 km east of Maintirano in the Melaky Region (Figure 15-1).

The forest is an isolated block of ca. 17,100 ha (for further details see Chatelain *et al*., 2013). The forest represents dry deciduous to semi-deciduous forest on limestone (*tsingy*) and on white sand, surrounded by secondary grasslands on lateritic and ferrous soils.

We surveyed three 1-km transects during diurnal and nocturnal transect walks (all lemur species) and performed line trapping targeting small nocturnal lemurs (*Microcebus* and *Mirza*) on two of these transects. The exact locations of the transects were for transect N (start: 18°01'58.6"S, 44°30'08.4"E; end: 18°01'17.7"S, 44°30'38.9"E), transect S1 (start: 18°03'42.6"S, 44°31'29.6"E; end: 18°03'58.6"S, 44°31'48.8"E) and transect S2 (start: 18°01'16.02"S, 44°30'49.86"E; end: 18°1'16.02"S, 44°30'49.86"E). Each transect was slowly walked (1 km/h) by three trained observers. Transects were walked once at night between 6:30 and 9:30 pm and twice at day between 8:00 and 11:00 am and 3:00 and 5:30 pm, periods covering peak lemur activity. An attempt was made to identify every viewed individual to species/genus level. For each sighting, we estimated distance from the transect line and determined the position on the transect by GPS. In March 2010, the same transects were surveyed by nocturnal and diurnal walks, between 6:30 and 9:30 pm and 3:00 and 5:30 pm, respectively. Additionally, we recorded all species-specific vocalizations as indicators of the presence of a taxon.

Trap-lines consisted of one small Sherman live trap (7.7 x 7.7 x 30.5 cm) every 25 m and one large Sherman live trap (10 x 11 x 38 cm) every 50 m along each transect, which were set during three consecutive nights. Sixty-two traps per transect were opened and baited with banana at dusk and checked and closed in the early morning. Additionally, we set six Tomahawk traps on one of the two transects. Every captured animal was briefly anaesthetized, identified to species, sexed, weighed, and standard morphometric measures were taken. To facilitate species identification small tissue samples were taken for later DNA extraction and genetic analysis. All animals were released at the site of capture shortly before dusk on the same day.

Results

In total, we confirmed the presence of 11 lemur species in the Beanka Forest (Table 15-1). Only *Microcebus myoxinus* was captured in traps placed on the line-transects. The presence of *Cheirogaleus medius*, *Cheirogaleus* sp. indet., *Phaner pallescens*, *Lepilemur* cf. *randrianasoli*, *Propithecus deckenii*, *Avahi cleesei*, and *Eulemur rufus* were confirmed by sightings and species typical vocalizations. Individual *Mirza* were sighted in high density and with dark tail tips, typical of *M*. *zaza*, and these individuals were also vocalizing frequently, untypical of *M*. *coquereli* in August. In five cases, *Microcebus* encountered during the nocturnal transects resembled *M*. *myoxinus* in coloration and relative size of the ears to the head width (see below); three individual *Microcebus* could not unambiguously be identified to species. In addition, we found typical feeding traces and large nests (ca. 80 cm diameter) most likely indicating the presence of *Daubentonia madagascariensis*.

We captured in total five adult *Microcebus* (3 males, 2 females), which resembled *M. myoxinus* as described by Rasoloarison *et al*. (2000) in coloration and morphometry. Individuals showed the typical

Table 15-1. Lemur species present in the Beanka Forest as confirmed by two rapid lemur surveys along three 1-km transects in August 2010 (Transect N, S1, and S2) and in March 2010 (Transect S2) and personal communications with other field workers.

Species	Transect N	Transect S1	Transect S2*	Other sources
Cheirogaleus sp. indet.			s	
Cheirogaleus medius			s	
Microcebus myoxinus	c, s	c, s	s	
Mirza sp.	s	s	s	
Phaner pallescens	s	s	s	
Lepilemur cf. *randrianasoli*	s	s	s	
Propithecus deckenii	s	s	s	
Avahi cleesei		s	s	s (S.M. Goodman)
Eulemur rufus	s	s	s	
Hapalemur cf. *griseus*				s (R. Randalana)
Daubentonia madagascariensis		t		s (R. Randalana)

c: capture, s: sighting, t: traces and nest, and v: vocalization.
*This transect was only surveyed and no trap-line was established.

Table 15-2. Morphometry (mean ± SD) and body mass of *Microcebus myoxinus* (n = 5) captured in the Beanka Forest in comparison to individuals (n = 4) from northern Menabe, south of the Manambolo River (Dammhahn *et al*., 2010), and data presented in Rasoloarison *et al*. (2000).

	M. myoxinus (Beanka)	*M. myoxinus* (northern Menabe)[1]	*M. myoxinus* (n = 15)[2]
Body length (mm)	85.4 ± 4.5	93.0 ± 8.7	
Head length (mm)	33.4 ± 0.7	32.9 ± 1.4	
Head width (mm)	21.0 ± 0.5	21.1 ± 0.9	
Ear length (mm)	17.7 ± 0.8	18.7	21.2 ± 1.2
Body mass (g)	41.2 ± 3.6	45.3 ± 5.3	49.0 ± 6.3

[1]Dammhahn *et al*. (2010); [2]Rasoloarison *et al*. (2000).

rufus-brown dorsum and the distinct rufus-red head of this species and were similar in several body measurements (body length, head length, and head width) to *M*. *myoxinus* from other locations (Table 15-2). In particular, the captured *Microcebus* were smaller than the potentially coexisting species, *M. murinus*, as well as having significantly smaller ears (Table 15-2). The anticipated local occurrence of *M*. *murinus* could not be confirmed by captured or observed animals. Until results from genetic work are available, it is prudent to refer all locally occurring *Microcebus* to *M*. *myoxinus*.

Discussion

The rapid lemur surveys in combination with hitherto unpublished information confirm the presence of 11 primate species from all five living lemur families in the Beanka Forest (Table 15-1). This species diversity is considerable and exceeds those of other dry deciduous forests. For example, the Kirindy Forest, south of the Tsiribihina River, and the Ankarafantsika National Park, north of the Betsiboka River, both have eight lemur species representing four families (Ganzhorn & Kappeler, 1996; Schmid & Rasoloarison, 2002). Among the western dry deciduous forests, only the Tsingy du Bemaraha area harbors comparable lemur diversity with 12 species (Rakotoarison *et al*., 1993; Thalmann & Rakotoarison, 1994) (Appendix 15-1). Hence, the large zone of microendemism north of the Tsiribihina and south of the Betsiboka River is characterized by the highest lemur diversity in western Madagascar. However, this area has received relatively little scientific attention, although it provides an interesting case to test biogeographical hypotheses associated with the distribution of lemur species. In the following, we (1) discuss the presence of different species in the Beanka Forest in relation to published data of their geographical range with respect to the local microendemism zone, and (2) evaluate these distribution data according to predictions of the centers-of-endemism hypothesis (Wilmé *et al*., 2006). Finally, we draw attention to immediate conservation risks of the lemurs of the Beanka Forest.

Primates of the Beanka Forest

According to Rasoloarison *et al*. (2000), *Microcebus myoxinus* occurs between the Tsirihibina River in the south and north to the Soalala Peninsula. Several areas with extensive survey work confirmed this species' southern limit as the Tsiribihina River with another small reddish mouse lemur, *M*. *berthae*, occurring south of the river in the Central Menabe (Dammhahn *et al*., 2010; Schäffler, 2012). The presence of *M*. *myoxinus* was further confirmed south of the Manambolo River, specifically in the Amboalimena Forest, near Belo sur Tsiribihina (Rasoloarison *et al*., 2000; Dammhahn *et al*., 2010). To the north, the occurrence of *M*. *myoxinus* was reported from the northern bank of the Manambolo River (Thalmann & Rakotoarison, 1994; S. M. Goodman, personal communication), the Tsingy du Bemaraha National Park, the Tsingy de Namoroka National Park (Rakotoarison *et al*., 1993; Rasoloarison *et al*., 2000), the Andranomanitsy Forest (Ralison, 2007), and potentially up to the Baly Bay area (Hawkins *et al*., 1998) (Appendix 15-1). Beyond the Betsiboka River, there is evidence for the presence of other mouse lemur species (Olivieri *et al*., 2007). Based on capture and sightings, *M*. *myoxinus* was found to be present at Beanka. Thus, as predicted by Wilmé *et al*. (2006), this taxon appears to be endemic to the inter-river Tsiribihina-Betsiboka zone. Throughout its distributional range, *M*. *myoxinus* is supposed to co-occur with the widely distributed *M*. *murinus*. In a previous rapid lemur survey south of the Manambolo, we found both species syntopic (Dammhahn *et al*., 2010), suggesting ecological niche differentiation between these congeners as has been described for other coexisiting mouse lemur species pairs (Radespiel *et al*., 2006; Dammhahn & Kappeler, 2008a, 2010; Rakotondranary *et al*., 2011; Thorén *et al*., 2011a, 2011b). During our rapid surveys in the Beanka Forest, the presence of *M*. *murinus* could not be confirmed. Since mouse lemurs often show patchy distributions over continuous forests (e.g. Fredsted *et al*., 2004; Dammhahn & Kappeler, 2008b; Rakotondravony & Radespiel, 2009), more detailed survey data are needed to clarify the presence or absence of *M*. *murinus* at Beanka.

During one of the rapid lemur surveys in the Beanka Forest, which was conducted during the dry season, we could not assess the presence of *Cheirogaleus*. Members of this genus are known to hibernate during this period (Dausmann *et al*., 2004). During the March survey, individuals of *C. medius* and of a larger *Cheirogaleus* sp. were observed. This sighted individual resembled the *Cheirogaleus* individual also reported from the Bongolava region (Thalmann, 2000). In the light of the strong torch, the animal was deep brown-reddish. The night sighting did not allow for a more detailed reliable morphological assessment. However, confusion with other lemurs present in Beanka can be excluded. The animal was distinctly larger than *C*. *medius* and clearly differed in its brown-reddish coloration. The short ears, entire habitus and locomotor behavior exclude confusion with *Mirza*. There are several reports of the presence of larger *Cheirogaleus* within the range of *C*. *medius* from the Bongolava, west of Tsiroanomandidy (Petter *et al.,* 1977; Thalmann, 2000) and the Bemaraha Massif (Thalmann & Rakotoarison, 1994; Ausilio & Raveloarinoro, 1998).

The distribution and determination of the larger *Cheirogaleus* taxon in western Madagascar remains unclear and awaits genetic material to verify the locally occurring species (Groeneveld, 2008). For the time being, the larger *Cheirogaleus* species is designated herein as *Cheirogaleus* sp. indet. The sympatry of *C. medius* and a larger *Cheirogaleus* in the Beanka Forest would offer a unique opportunity to study ecological niche differentiation between smaller and larger dwarf lemurs in dry forests as compared to more humid forests in south-eastern and eastern Madagascar (Lahann, 2007). As pointed out by Groeneveld (2008), the wide distribution of both species over several centers of microendemism cannot be explained by the centers-of-endemism hypothesis (Wilmé *et al*., 2006).

With the exception of the subhumid forests of the western slopes of the Manongarivo Massif, the genus *Mirza* is limited to the western dry deciduous forest and apparently has a notably disjunct distribution with a prominent gap of several hundred kilometers between the northern populations, now recognized as a distinct species, *M*. *zaza* (Kappeler *et al*., 2005), and the southern population, *M*. *coquereli*. In a recent survey, Markolf *et al*. (2008) reported that the distribution of *M*. *zaza* is restricted to only a few, mostly highly degraded forests. Given that an individual from Bemaraha genetically resembles *M*. *coquereli*, Markolf *et al.* (2008) suggested that the Betsiboka River might be the northern limit for *M*. *coquereli*. Following this, the distribution of *M*. *coquereli* is notably broad, reaching from the Onilahy River in the south to the Tsingy de Namoroka National Park (Mittermeier *et al*., 2010) in the central west. However, due to a lack of lemur survey data from the Maintirano region, as well as from Namoroka, the northern limits of *M*. *coquereli* are still unclear.

During our surveys, we frequently encountered *Mirza* during nocturnal transect walks but no individual was captured. We often observed particularly vocal individuals in close proximity to one another. This behavior is atypical for the solitarily foraging *M*. *coquereli* and occurs in this species only during the short annual mating season (Kappeler, 1997). In contrast, *M*. *zaza* appears to show higher levels of gregariousness with males and females frequently sharing sleeping sites (Kappeler *et al*., 2005; Rode *et al*., 2013). Based on the capture of pregnant females, Kappeler *et al*. (2005) suggested that the mating season of *M*. *zaza* at Ambato is July-August, which would match our observations of high levels of gregariousness between *Mirza* individuals in the Beanka Forest in August. More precise determination of the *Mirza* sp. occurring at Beanka awaits morphological and genetic data.

The four species of *Phaner* currently recognized on Madagascar show a discontinuous distribution with *P*. *pallescens* occurring in the western dry deciduous forests, from the Fiherenana River (including the Mikea Forest) in the south to the Soalala region in the north (Groves & Tattersall, 1991; Mittermeier *et al*., 2010). Thus, it shows a wider distribution than expected by the centers-of-endemism hypothesis (Wilmé *et al*., 2006). In the area between the Tsiribihina and the Betsiboka Rivers, it has been reported from north and south of the Manambolo River (Thalmann & Rakotoarison, 1994; Dammhahn *et al*., 2010), from the Tsingy du Bemaraha National Park (Rakotoarison *et al*., 1993), the Tsingy de Namoroka National Park (Thalmann *et al*., 1999), and the Baly Bay area (Hawkins *et al*., 1998). In the Beanka Forest, we encountered individuals resembling *P. pallescens* in external characters, such as light grey dorsal coat and dark coloration of the tail extending to about half its length, and vocalizing animals in high densities on all nocturnal transects.

In a recent taxonomic revision of the genus *Lepilemur*, Andriaholinirina *et al*. (2006) assigned samples from the area north of the Tsiribihina River to a new species, *L. randrianasoli*, which differs from *L. ruficaudatus* to the south in its karyotype, slightly smaller body size, and having a narrower and longer head. Currently, this species is restricted to the type locality (Andramasay, Toliara Province) and the Tsingy du Bemaraha National Park and Strict Nature Reserve with the Tsiribihina River forming the southern limit (Andriaholinirina *et al*., 2006; Dammhahn *et al*., 2010). Thus, this species most likely has a very limited distribution. This combined with ongoing forest habitat loss in the area, underlines the taxon's high conservation priority, but critical details on its geographic distribution are lacking.

The *Lepilemur* observed in the Beanka Forest resembled *L. randrianasoli* in the area north of the Tsiribihina River in body size and coloration (Andriaholinirina *et al*., 2006; Dammhahn *et al*., 2010). Since the more recently described species, *L. ahmansoni*, was named from the Tsiombikibo region, southwest of the Mahavavy River, based on genetic characters (Louis *et al*., 2006a), the species determination of the Beanka Forest *Lepilemur* needs be confirmed by genetic data. *Lepilemur* sp. occurred in high densities with up to nine individuals encountered along a 1-km transect. Thus, the presence of *L.* cf. *randrianasoli* at Beanka would extend its currently known distribution further to the north. Whether the species' range extends to the north up to the Betsiboka River, as predicted by Wilmé *et al*. (2006), or it is indeed replaced by the *L. ahmansoni* needs further clarification.

Based on coloration characteristics, Thalmann & Geissmann (2005) described a new species of woolly lemur, *Avahi cleesei*, from three sites in the Tsingy du Bemaraha region north of the Manambolo River. This has been supported with genetic data (Andriantompohavana *et al*., 2007). The limits of this species' distribution are unknown but it was assumed to be restricted to an area of 5000 km² (Thalmann & Geissmann, 2006), and classified as endangered by the IUCN (2013). Since the Beanka Forest is the geographical continuation of the Tsingy du Bemaraha forests (see Gautier *et al.*, 2013 for further details), the local presence of *A. cleesei* was anticipated and confirmed by our field observations. Individuals were encountered frequently on all three transects in habitat similar to the semi-deciduous and dry deciduous forests of the Tsingy du Bemaraha, where preliminary information on the species ecology was collected (Thalmann & Geissmann, 2006). The occurrence of *A. cleesei* in the Beanka Forest suggests that it has a wider distribution than previously thought, but is nonetheless a typical representative of the local zone of microendemism. Further data on the southern and northern limits of this species' range are required.

The biogeographical region between the Tsiribihina and the Mahavavy du Sud Rivers represents the complete range of *Propithecus deckenii*, which served as an empirical example to support the centers-of-endemism hypothesis (Wilmé *et al*., 2006). This species has been encountered in various undisturbed to degraded forests in the Baly Bay area (Hawkins *et al*., 1998), in the Tsingy du Bemaraha National Park (Rakotoarison *et al*., 1993), and the Tsingy de Namoroka National Park (Thalmann *et al*., 1999). During our surveys, we encountered *P. deckenii* in high density, with up to four groups, each with 4-6 individuals, along 1-km transects. The Beanka Forest might provide an ideal setting to study the behavior and ecology of this little-known *Propithecus*.

The biogeographical distribution of the *Eulemur* spp. extend over wide areas of western, eastern, and central Madagascar and, thus, over different retreat-dispersion watersheds and centers of endemism (Wilmé *et al*., 2006). Populations north of the Tsiribihina River were recently raised to species level by Groves (2006) and named *E. rufus*. An extensive taxonomic study using different datasets to delimit species in the genus *Eulemur* (Markolf *et al.*, 2013) is concordant with Groves' taxonomic decision. Accordingly, individuals encountered at Beanka represent *E. rufus* and resemble individuals at Bemaraha, Katsepy, and Madirovalo, all located north of the Tsiribihina, in mitochondrial DNA, vocalizations and coloration. *Eulemur rufus* is also known from the Baly Bay area (Hawkins *et al*., 1998) and the Tsingy de Namoroka National Park (Thalmann *et al*., 1999). In the Beanka Forest, we encountered 1-2 groups of at least seven individuals. Groups were extremely shy, indicating local human hunting pressure. Overall, concerning this species, distribution, and new genetic data are concordant with the centers-of-endemism hypothesis (Markolf & Kappeler, 2013).

Several surveys reported the presence of *Hapalemur* in the microendemism zone which includes the Beanka Forest, including sightings in the Tsingy du Bemaraha National Park and Strict Nature Reserve (Rakotoarison *et al.*, 1993), the Tsingy de Namoroka National Park (Thalmann *et al.*, 1999), the Baly Bay area (Hawkins *et al.*, 1998), and the Tsiombikibo Forest close to Mitsinjo (Curtis *et al.,* 1995). However, the taxonomic status of the locally occurring form is unclear. Based on cytogenetics of one individual, the western *Hapalemur* is considered *H. griseus ranomafanensis*, which has a discontinuous distribution also including eastern humid forests (Rabarivola *et al.*, 2007; Mittermeier *et al.*, 2010). In the Beanka Forest, *H.* cf. *griseus* appears to be present in bamboo areas (R. Randalana, personal communication). The ecology and behavior of this species remains to be studied in detail. Since western *Hapalemur* can occur in areas where bamboo is not abundant, they might be less dependent on this resource than in the eastern humid forests (Tan, 1999).

Daubentonia madagascariensis has a wider distribution than previously thought (Mittermeier *et al.*, 2010). This species' range includes the eastern rain forests as well as the western dry deciduous forests north of the Tsiribihina River. Thus, it does not appear to be restricted to one microendemism area. In accordance with the centers-of-endemism hypothesis (Wilmé *et al.*, 2006), however, a recent population genomic analysis revealed local genetic structure in northern populations (Perry *et al.*, 2013). Overall, local densities of *D. madagascariensis* appear to be low, highlighting the importance to assess distribution and gene flow between remaining populations. In western Madagascar, Tattersall (1982) reports this species from southeast of the Baly Bay, which is north of the Beanka Forest. It is found in the Tsingy du Bemaraha National Park (Rakotoarison *et al.*, 1993) and in the Tsingy de Namoroka National Park (Thalmann *et al.*, 1999). In the Beanka Forest, we found feeding traces of this species and the typical large nests; no individual was directly observed during our surveys, but local records have been confirmed (R. Randalana, personal communication).

The Beanka Forest: a forest under some threat

The extraordinarily high diversity of lemur species and other plant and animal taxa qualify the Beanka Forest as an area of highest conservation priority among the dry deciduous forests of western Madagascar – the hottest hotspots of biodiversity (Ganzhorn *et al.*, 2001). Due to its relatively small size, elongated shape, geographic isolation, and the presence of 17 villages in the immediate surroundings, the Beanka Forest is prone to habitat fragmentation (see Chatelain *et al.*, 2013). The majority of the remaining forest is on the less accessible limestone formation (*tsingy*) and the surrounding forest has been severely fragmented.

During the short periods of our surveys, we identified several potential threats for the protection of the Beanka Forest. First, fire remains a clear local problem, with forest having been damaged up to the limestone plateau associated with escaped fires to regenerate cattle pasture. Repeated burns at the forest edge induce habitat degradation and destruction.

Several introduced species might affect the native species community. We captured rats (*Rattus rattus*) in transect S1. Although the presence of rats might not directly affect the distribution of lemurs (Ganzhorn, 2003), they are known to introduce parasites into small mammal communities (Sommer, 2007) and to negatively affect other native vertebrates. Further, several non-indigenous carnivorans are present in the Beanka Forest and might negatively impact the lemur community. Stray dogs (*Canis familiaris*) were observed regularly even in the forest core (R. Randalana, personal communication). Furthermore, we observed wildcats (*Felis silvestris*) in the forest, a species that might predate on large lemurs such as *Propithecus verreauxi* (Brockman *et al.*, 2008).

Conclusions

Although our study contributed new data to the lemur community of the Beanka Forest and on the ranges of several poorly known lemur species, several questions remain unanswered. In particular, the species of locally occurring *Cheirogaleus*, *Lepilemur*, *Hapalemur*, and *Mirza* need to be determined based on morphological and genetic data. Lemur distribution in the zone between the Tsiribihina River in the south and the Betsiboka River in the north, including the Beanka Forest, only partly support the centers-of-endemism hypothesis (Wilmé *et al.*, 2006). Given its extraordinarily high lemur diversity and several conservation threats, the Beanka Forest certainly deserves more scientific attention from researchers studying lemur ecology and behavior. Current programs of Biodiversity Conservation Madagascar are important for the conservation of this forest area.

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Appendix 15-1. Summary of published results from primate surveys of the region between the Tsirihibina and Betsiboka Rivers, including the Beanka Forest, locations are sorted from south to north.

Species	**South of the Manambolo River[1,2]**	**North of the Manambolo River[1]**	**Tsingy de Bemaraha[1,3]**	**Beanka Forest***	**Tsingy de Namoroka[4]**	**Baly Bay area[5]**	**Anjamena[6]**
Cheirogaleus sp. indet.	s		s	s			
Cheirogaleus medius	s	s	s	s	i	s	
Microcebus murinus	s	s	s		s (*Microcebus* sp.)	s	s
Microcebus myoxinus	s	s (*Microcebus* sp.)		c, s	s (*Microcebus* sp.)	(s) (*Microcebus* sp.)	
Mirza coquereli	s	s	s	s (*Mirza* sp.)			
Phaner pallescens	s	s (*P. furcifer*)	s (*P. furcifer*)	s	s (*P. furcifer*)	v, s (*P. furcifer*)	
Lepilemur cf. *randrianasoli*	s (*L.?edwardsi*)[1]	s (*L.?edwardsi*)	s (*L. ?edwardsi*)	s	s (*Lepilemur* sp.)	s (*L. ruficaudatus*)	s (*Lepilemur* sp.)
Propithecus coronatus							s
Propithecus deckenii		s	s	s	s	s	s
Avahi cleesei			s	v, s			
Eulemur rufus	s	s	s	s	s	s	s
Eulemur mongoz							s
Hapalemur cf. *griseus*	v *(H. occidentalis)*	s *(H. occidentalis)*	s *(H. occidentalis)*	s	s *(H. occidentalis)*	s *(H. occidentalis)*	
Daubentonia madagascariensis	t	t	s	s	s		

* Our survey and personal communications by R. Randanala & S. M. Goodman; [1]Thalmann & Rakotoarison (1994), [2]Dammhahn *et al*. (2010), [3]Rakotoarison *et al*. (1993), [4]Thalmann *et al*. (1999), [5]Hawkins *et al*. (1998), [6]Müller *et al*. (2000).

s: sightings, v: species typical vocalization, t: species typical traces, and i: species presence indicated by interviews.