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A Biological Inventory of the Lemur Community of Réserve Spéciale de Kalambatritra, South-Central Madagascar

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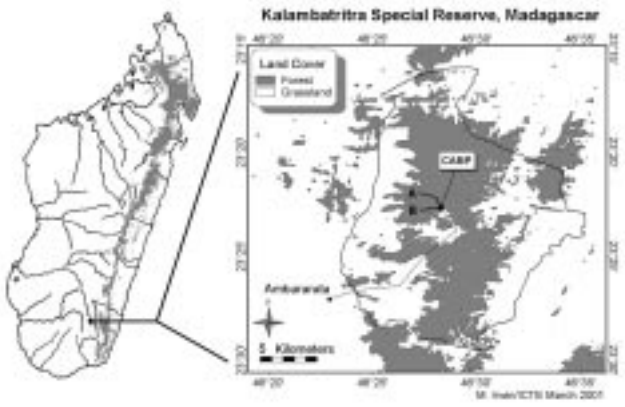
Many of Madagascar's protected areas have been the focus of long-term intensive study, and are therefore well-known in terms of their lemur community, and biology in general (e.g. Ranomafana National Park, Berenty Private Reserve, Beza-Mahafaly Special Reserve). However, even today, some protected areas remain largely unstudied. While long-term and intensive study is of great value, it is also important that efforts be made to directly survey poorly-known protected and unprotected forests, in order to gather accurate baseline knowledge of species' ranges and conservation status.

Kalambatritra Special Reserve (23º15'-23º29' S, 46º23'-46º36' E; 28,250 ha; elevation 740-1680 m) is located in southern central Madagascar, in both Fianarantsoa and Toliara provinces (Fig. 1). It is unique in that it lies significantly further west than any comparable rainforest in southeastern Madagascar, and straddles the continental divide between eastern (Mananara) and western (Mangoky/Onilahy) drainages. Approximately 45 % of the reserve is covered by largely continuous primary rainforest (elevation 1200-1680 m), including one large massif in the northern central part of the reserve (Ambalabe), a smaller massif in the south, and several smaller patches. This forest is not directly continuous with the main eastern rainforest corridor (a non-forested break of approx. 16 km exists between forests extending southeast from Kalambatritra and Midongy-du-Sud National Park). The remainder of Kalambatritra's land area is covered with grassland containing an ex-



Fig, 1: Location of RS Kalambatritra. Forest cover for Madagascar from Green and Sussman (1990); forest cover for Kalambatritra from a 1999 Landsat 7 satellite image. A, B denote census trails, dashed line indicates trail from Ambararata to survey camp.

tremely low human population density and very little cultivated land. It is difficult to determine whether this grassland is natural or anthropogenic (e.g. MacPhee *et al.* 1985); however, a comparison of topographic maps reporting land cover from aerial photographs taken in the 1950s (FTM 1972,1974) with a Landsat 7 satellite image from October 1999 reveal that little or no deforestation has taken place within this time (M. Irwin, unpublished data).

Very little research has been conducted within RS Kalambatritra and little is known about its flora and fauna. To our knowledge, only five biological expeditions have been conducted within the reserve: Nicoll and Langrand (brief biological survey, 1989), Nussbaum (1995, results not available), a Belgian University (results not available), ZICOMA (ornithological survey, 1998), and Intercoopération Suisse/ Marie E.R.T.A. (biological inventory, 1999).

The survey of Nicoll and Langrand (1989) was brief (M. Nicoll, pers. comm. to P. Wright), and reported the presence of four lemur species: *Eulemur fulvus rufus*, *Lemur catta* (in the gallery forests west of the reserve) and two unnamed nocturnals. The ZICOMA survey (ZICOMA 1999) reported the presence of four lemur species: *Hapalemur griseus griseus*, *Eulemur fulvus collaris*, *Eulemur rubriventer*, and *Lepilemur* sp. The Intercoopération Suisse/Marie E.R.T.A. survey (Intercoopération Suisse/Marie E.R.T.A. 1999b) reported the presence of five lemur species: *Microcebus rufus*, *Lepilemur* cf. *mustelinus*, *Hapalemur g. griseus*, *Lemur catta, and Eulemur fulvus rufus.*

Despite these previous efforts, characterization of Kalambatritra's lemur community remains uncertain. In particular, the following questions remain unanswered:

1. Which subspecies of *Eulemur fulvus* is present? The existence of conflicting reports requires clarification.
2. Is the family Indridae truly absent? The absence of this family (particularly *Avahi*, which is widespread) would be unusual among eastern rainforest localities and requires verification.

The surveys to date are inadequate to answer these questions. As mentioned above, Nicoll and Langrand (1989) apparently did not penetrate the large forest blocks of Kalambatritra, nor did the Intercoopération survey (see Intercoopération Suisse/Marie E.R.T.A. 1999b: 32). Both of the Intercoopération study sites were located in patchy forest (SW and SE of Ambalabe), and none of the ¨Points de passage des équipes¨ were more than 1.5 km from the forest edge. In addition, their report gives no details of their primate census methodology or sampling effort. It is therefore impossible to know whether this survey detected all possible lemur species. Finally, none of the five previous expeditions are known to have included primate specialists.

An adequate characterization of Kalambatritra's lemur community is desired for two reasons. First, researchers examining the effects of community composition on lemur ecology can test theories by studying in forests of differing lemur composition. If Kalambatritra truly lacks the family Indridae, it could offer a valuable opportunity for researchers interested in the presence of this family on other folivorous lemurs (e.g. *Lepilemur*). Secondly, in order to develop an effective management plan for the reserve, it is important to know the composition of the lemur community. Among Madagascar's native flora and fauna, lemurs remain one of the most popular tourist attractions. In order to predict a reserve's viability as a tourist attraction, it is important to first know which lemurs are present, and how easy they are to see (e.g. distribution and abundance).

The primary goal of the present study is to characterize the lemur community of RS Kalambatritra (species richness, distribution, and abundance), and specifically address the two questions listed above. To accomplish this, we penetrated the larger forest block in the northern half of the reserve (23º21' S, 46º28' E), which has never before been visited by a primatological survey team. The survey took place between 18 and 26 June, 2000.

Methods

Line-transect censusing

Two 2-km trails were established in the study area (Fig. 1). Because no trails existed in the study area, it was necessary to cut trails. Standard line-transect census methodology (Struhsaker 1981; Whitesides *et al.* 1988; Johnson and Overdorff 1999) was employed. A total of 21 diurnal censuses were conducted, both in the morning (approximately 8:00 to 10:00) and in the afternoon (approx. 15:00 to 17:00). In addition, nine nocturnal censuses (approx. 18:00 to 20:00) were conducted. The distance sampled was 31.56 km for diurnal census (14.56 km trail A + 17 km trail B) and 6.965 km for nocturnal census (1.965 km trail A + 5 km trail B).

Diurnal lemur densities were calculated using the perpendicular-distance method (Whitesides *et al.* 1988), using a fall-off distance of 20 m and a strip width of 48 m (24 m each side of the trail). Although the sample size of the present survey was inadequate to accurately determine a specific fall-off distance for Kalambatritra, the fall-off distance of approx. 20 m has been determined from previous surveys in the southeastern rainforests (Irwin *et al.* 2000b; P.C. Wright, unpub. data). Average perpendicular sighting distances at Kalambatritra were similar to those of the other surveys (Irwin *et al.* 2000a, unpublished data). For the nocturnal *Lepilemur*, the average perpendicular sighting distance was almost exactly half that of diurnal species; therefore a strip width of 24 m (12 m each side of the trail) was used.

Botanical Assessment

Three botanical transects were established along each 2-km census trail, evenly spaced at 400 m intervals (total = 6 transects). At each location, a 10 m by 100 m transect was established perpendicular to the trail. For all trees over 10 cm diameter at breast height (dbh), the following data were recorded: local name, dbh, height and crown diameter. In order to census smaller trees and lianas, additional 5 m by 5 m plots were established within each botanical transect, in which all trees or lianas regardless of size were inventoried.

Assessment of Forest Disturbance and Hunting

Evidence of human disturbance (e.g. trees felled, tavy, traps, human habitation) was noted whenever encountered. In addition, interviews with local people, whenever possible, were conducted in order to determine the nature and extent of forest use and hunting practices.

Results

Study Site

Our camp (23º22.4' S, 46º28.2' E) was established within Ambalabe, the largest continuous forest block found in RS Kalambatritra. Note that the FTM topographic map (FTM, 1972) contains an error: the area labelled «Befarafara» (23º23' S, 46º27' E) is known locally as «Ambalabe», while the forest approximately 5 km to the east (23º23' S, 46º30' E) is known as «Befarafara». Our camp was approximately 12.4 km NE of Ambararata (23º27.0' S, 46º22.8' E), and 5.7 km ESE of Ambaro (23º21.1' S, 46º25.1' E). We established two 2 km census trails, Trail A (starting approximately 0.5 km north of camp and continuing west) and Trail B (starting near camp and continuing roughly west. Elevation of the study area is approx. 1400-1680 m. The site was accessed by driving through Ihosy and Betroka to Ivahona (23º27.3' S, 46º10.3' E) and hiking from there (approximately 32 km).

Lemur Census

Results are summarized in Table 1. Two diurnal species were seen: *Eulemur fulvus collaris* and *Hapalemur griseus* ssp. A third, *Lemur catta*, was not directly observed but locals testified that it exists in gallery forests to the west of the study area. Two nocturnal species were seen: *Lepilemur* sp. and *Microcebus rufus*. Traces of a third species (*Daubentonia madagascariensis*) were also seen.

Table 1: Census results.

Species	Census Sightings		Sightings per km walked	Group density (groups/km^2)	Minimum Number of Groups
	Trail A	Trail B			
Eulemur fulvus collaris	5	2	0.22	4.62[a]	4
Hapalemur griseus ssp.	4	2	0.19	3.96[a]	4
Daubentonia madagascariensis	0	0	0	-	1++
Lepilemur sp.	7	5	1.72	71.79[b,c]	4
Microcebus rufus	0	2	0.29	-	1

a. using strip width of 48 m (see Methods); b. using strip width of 24 m (see Methods); c. equals individual density (all encounters were with lone animals)

Eulemur fulvus collaris (local name = *Varika*/*Varikabe*): Most individuals seen matched published descriptions of this subspecies and were easily distinguished from other subspecies of *Eulemur fulvus*, including *E. f. rufus* (e.g. Mittermeier *et al.* 1994). However, there was some variation in beard color: some individuals had orange beards while others had lighter (almost white) beards. Although Kalambatritra is not far from the known range of *E. f. albocollaris*, it seems most likely that the animals observed here represent one slightly variable population of *E. f. collaris*. The mean number of individuals per sighting was 3.3, with a range of one (a lone adult male) to five (three males, two females).

Hapalemur griseus ssp. (local name = *Varika* / *Varikakely*): Much phenotypic variation was observed among the individuals of this species. Some individuals appeared to be much larger than is known for wild *H. g. griseus* (visual estimates of >1.5 kg), had darker brown pelage and larger, more projecting, rounded ears with a white fringe. However, other individuals were much smaller (visual estimate <1 kg) with greyer pelage, and smaller, inconspicuous ears (closely matching published descriptions of *H. g. griseus*; e.g. Mittermeier *et al*. 1994). We strongly believe that these animals represent *H. griseus* rather than *H. simus* or *H. aureus*, based on overall pelage as well as distinctive vocalizations. However, it remains possible that this population represents *H. g. meridionalis* or a novel subspecies. The mean number of individuals per sighting was 2.2 (range 1 to >5).

Daubentonia madagascariensis: Several feeding traces of this species were found (tooth gouges), usually in dead and rotting palm trees (*Dypsis* sp.). Some of these traces were quite recent (less than one week old). No individuals were directly observed.

Lepilemur sp. (local name = *Trangalavaka*): This species was commonly observed on both transects and appears to be quite abundant at the study site. All individuals observed were brown in color, with a tail which became dark towards the tip, and white below the chin. Little or no dorsal stripe was observed. All encounters were with lone individuals, and an extremely high population is extrapolated (71.79 individuals / km^2). This would be equivalent to a spatially continuous population of pairs each having home range 2.8 ha.

Intercoopération and Marie E.R.T.A. (1999b) report that the *Lepilemur* individuals they encountered appeared to belong to *L. mustelinus*, previously known only from significantly further north (north of approximately 18°S). However, no individuals were captured during the course of their study or the present study; any species designation is therefore highly speculative. Capture and DNA analyses would be necessary to definitively diagnose this population, and the most parsimonious alternatives are *L. microdon* (found in the southeastern rainforests, to the east of Kalambatritra), *L. leucopus* (found in the dry forests of southern Madagascar, south of Kalambatritra) or *L. ruficaudatus* (found in the dry forests of southwestern Madagascar, west of Kalambatritra).

A *Lepilemur* latrine was encountered on trail A. A large pile of feces (diameter 0.5 m, depth approx. 5 cm) was found at the base of a Hafitra tree (*Dombeya* sp.), and that tree, along with several other Hafitra trees in the vicinity, displayed several single scratches (1-2 cm long and 1-2 m above ground). A vigil revealed that the feces were those of *Lepilemur* sp., and the scratches are likely due to concurrent scentmarking. Other trees with similar traces (and one older pile of feces) were found elsewhere on the census trails, at great distance from the location mentioned above, suggesting that this behavior is common in the area. At present we do not believe this behavior has been previously reported in *Lepilemur* (or any other lemur species), and speculate that it may be a territorial response to their extremely high population density.

Microcebus rufus: This species was observed on two occasions on trail B. Phenotypically, the animal(s) observed seemed to fit the published descriptions of *M. rufus*.

The present survey found no evidence of *Propithecus* or *Avahi*, which is consistent with previous surveys, and adds further evidence indicating the absence of the family Indridae. This survey also found no evidence of *Eulemur rubriventer*, which was reportedly found by the ZICOMA survey (ZICOMA 1999). Further confirmation of this sighting is necessary, but the absence of *E. rubriventer* is consistent with its apparent absence at nearby PN Midongy-du-Sud. The failure to detect *Cheirogaleus* sp. is likely an artifact of the timing of the survey, during which most individuals would be expected to be in torpor.

Botanical Inventory

A total of 0.6 ha (305 trees) was sampled. Ambalabe contains primary forest with no evidence of disturbance. The canopy height averages approximately 25 meters, with several trees attaining heights of greater than 30 meters. Trees with dbh exceeding 2 m were routinely encountered in the transects. In both height and dbh, Kalambatritra contains consistently larger trees than comparable southeastern rainforest localities (Figure 2). In the largest parts of the forest, there exists a sharp distinction between the canopy and the herbaceous understory, which averages approximately 3 meters in height. Palm trees (*Dypsis* sp.) are conspicuous and frequently attain heights exceeding 25 m. 63 tree species were identified in the botanical transects; Table 2 presents the ten most abundant species (following Turk 1995).

Table 2: Common tree species at Kalambatritra.

Malagasy Name	Family	Scientific Name
Faho	Cyatheaceae	*Cyathea* sp.
Karambitona	Euphorbiaceae	*Macaranga myriolepidea*
Merana	Compositae	*Brachylaena merana*
Ramilevina	Compositae	*Apodocephala pauciflora*
Sandramy	Anacardiaceae	*Protorhus* sp.
Tavolo	Lauraceae	*Cryptocarya* sp.
Vakoana	Pandanaceae	*Pandanus* sp.
Vanana	Elaeocarpaceae	*Sloanea rodantha*
Varongy	Lauraceae	*Ocotea* sp.
Vatsilana	Araliaceae	*Schefflera* sp.

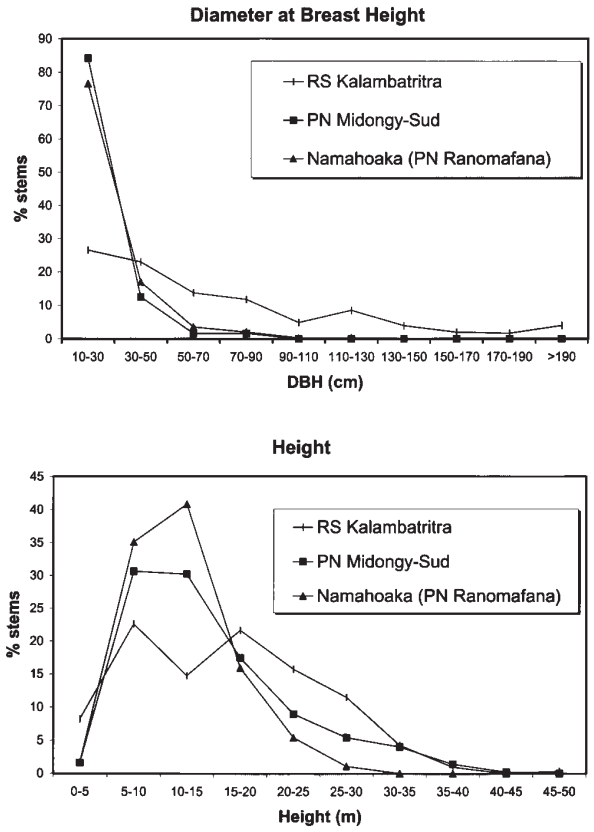


Fig. 2. Comparisons of Kalambatritra forest structure with two other southeastern rainforest localities (trees > 10 cm dbh). Midongy data from P. Wright (unpublished), Namahoaka from Irwin *et al.* (2000b). Area/No. of trees sampled: Kalambatritra, 0.6 ha/305; Midongy, 0.6 ha /424; Namahoaka, 1.0 ha /647.

Forest Disturbance

We saw traces of human presence (e.g. well-used trails, cut trees) in two smaller forest blocks that we passed through (Befarara and Befarafara) on the way to Ambalabe. However, within Ambalabe, no signs of human presence were observed near camp or on any of our trails (total length approx. 4.5 km). No existing trails for human or zebu use were encountered, nor were any human signs of any kind. Locals testified that some hunting of frugivorous lemurs is conducted within the rainy season, by clearing small areas within the forest and setting snares. However, such activities tend to leave traces which last for more than one year, and no such traces were encountered at Ambalabe. The absence of both traps and trails suggests that such activities probably occur closer to the forest edge. This study area is therefore extremely unique in showing absolutely no evidence of human use; few forests in Madagascar have been completely free of exploitation by humans. The primary reason for Kalambatritra's pristine nature is probably the extremely low human population density in the region, and the fact that Ambalabe is more than 5 km from the nearest village.

Discussion

The results of the present survey allow us to provide some answers to the questions posed here (see Introduction). First, contrary to the reports of Nicoll and Langrand (1989) and Intercoopération Suisse/Marie E.R.T.A. (1999b), the subspecies (or species; see Djelati *et al.* 1997, Wyner *et al.* 1999) of *Eulemur fulvus* represented is *E. f. collaris*. This is not surprising given that *E. f. collaris* is also found in PN Midongy-du-Sud, the closest well-known forest (approximately 40 km to the east). It appears that this lemur was misidentified both by the brief survey of Nicoll and Langrand (1989) and the supposedly more extensive Intercoopération survey (although they report encountering only two groups of *Eulemur fulvus*; Intercoopération Suisse/Marie E.R.T.A. 1999b: 73).

Second, it appears that the family Indridae is indeed absent from this forest. During eight days of data collection, we accumulated a large sampling effort for lemur censuses: almost 32 km for diurnal censuses and 7 km for nocturnal censuses (and a total of approx. 150 and 20 hours spent on the census trails during day and night, respectively). In addition, examination of the species accumulation curve reveals that all five species found by our survey were detected by the second of eight days of data collection, implying that the sampling effort was sufficient. Finally the large number of sightings of other species (e.g. 12 for *Lepilemur*) also suggests that the sampling effort was adequate.

Equally striking is the seemingly high population density of *Lepilemur*. It seems possible that the reason for this abundance is the absence of other folivores with which it might compete for food (*Propithecus* and *Avahi*; e.g. Ganzhorn 1993). This is an interesting biological phenomenon and worthy of further research in order to: (i) more definitively establish the absence of Indridae, (ii) determine which species of *Lepilemur* is present at Kalambatritra, and (iii) gain further understanding of the interspecific relationships among *Lepilemur, Propithecus*, and *Avahi* by studying *Lepilemur* in the absence of its two competitors.

There exists a slight possibility that *Propithecus* and/or *Avahi* do exist within RS Kalambatritra but remained undetected by our censuses. For example, they may exist in other regions of the reserve (although our study site was situated in the largest continuous forest block). However, our data suggest that even if *Propithecus* is present at Kalambatritra, they seem to exist in exceedingly low population densities. This in itself would be an interesting biological phenomenon, as *Lepilemur* is not often known to exist at high densities relative to its competitors in the southeast (e.g. PN Ranomafana).

Kalambatritra's species richness is fairly low for an eastern rainforest locality (5 species detected, 7 likely present, including *Lemur catta* and *Cheirogaleus* sp.). However, this reserve holds a unique assemblage of species, and therefore presents a unique research opportunity for those interested in lemur community dynamics. Unfortunately, the absence of many large-bodied diurnal lemur species (especially *Propithecus* and *Varecia*) means that Kalambatritra may be less attractive to tourists than other protected areas in the region (e.g. PN Andringitra, RS Manombo). Nevertheless, the pristine primary forest of Ambalabe is extremely impressive to behold, and it is our opinion that this alone could be one of the primary attractions of the reserve. In other parts of the world, forests of extreme size and age are protected and visited by tourists (e.g. temperate rainforests of western North America). Kalambatritra may prove to be truly exceptional within Madagascar in the size and age of its trees, and should be protected as an example of the potential of Malagasy forest in the absence of human disturbance.

The Intercoopération report concludes, because human pressures are currently very low at Kalambatritra, that "cette region ne constitue pas une priorité pour l'Etat" ("This region does not constitute a priority for Madagascar"; Intercoopération Suisse/Marie E.R.T.A. 1999a: 16). We strongly disagree with this assessment. Kalambatritra is unique in its biogeography, flora, and lemur and bird communities (including three rare and vulnerable bird species; Irwin *et al.* 2000a) and represents a rare example of pristine, undamaged eastern rainforest. Further inventories should be undertaken to examine the species composition and endemism of other groups of plants and animals. The unique biogeo-

graphic position of the reserve, coupled with its isolation from the continuous rainforest corridor to the east, means that such studies may well find new species and unique communities. Effective management plans should be implemented, and demographic and socio-economic changes in and around the reserve should be monitored carefully, in order to maintain the sanctity of this protected area.

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Indications for Hybridisation between Red-fronted Lemurs (*Eulemur fulvus rufus*) and Mongoose Lemurs (*E. mongoz*) in Northwest Madagascar

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Eulemur is the most diverse and widespread genus of the family Lemuridae, with five currently recognised species. The mongoose lemur, *Eulemur mongoz*, occurs in three geographically isolated populations; on two Comorian islands (Anjouan and Mohéli) and in northwest Madagascar. The brown lemur, *E. fulvus*, has the largest distribution of the five *Eulemur* species and contains at least six subspecies. Brown lemurs are found on the Comorian island Mayotte, in all forested areas of Madagascar except the South and. *E. fulvus* is found in sympatry with all four other *Eulemur* species, including *E. mongoz* in northwestern Madagascar (for review see Tattersall 1982; Harcourt and Thornback 1990; Mittermeier *et al.* 1994).
One of the authors (AZ) collaborated on a 10-month study on mongoose lemurs at Anjamena in northwestern Madagascar (Fig. 1) carried out by D.J. Curtis (Curtis and Zaramody 1998, 1999; Curtis *et al.* 1999). During the field work from September 1994 to September 1995, animals were observed which presented pelage coloration intermediate between *E. mongoz* and *E. f. rufus*. This phenotypic variation led to the suspicion that interspecific hybridisation might be occurring at this site (see Table 1 in Curtis and Zaramody 1998). However, apart from this anecdotal observation, no one has reported hybrids among *Eulemur* species in the wild and no genetic evidence has been published supporting that claim. Mongoose lemurs and brown lemurs represent well accepted discrete species which are phenotypically distinct.