THE EFFECTS OF FOREST DEGRADATION AND TRANSLOCATION ON *EULEMUR COLLARIS* BEHAVIOURAL ECOLOGY IN THE LITTORAL FORESTS OF SOUTHEASTERN MADAGASCAR

Giuseppe Donati, Department of Ethology, Ecology and Evolution, Unit of Anthropology, Via S. Maria 55, I-56126, Pisa, Italy. E-mail: donati18@interfree.it

Introduction

The littoral forests of southeastern Madagascar are among the most endangered habitats in the world. As in most of the threatened forests of Madagascar, the needs of the people of the area contribute to the reduction and degradation of these highly diverse and endemic ecosystems. The demand for fuelwood is continually increasing and leading to deforestation in the already greatly fragmented and degraded littoral forests. The Mandena forest fragments, in the South East corner of the island, in particular have suffered from such extreme pressures that its current size is only a fourth of its original extension (Fig. 1).

The collared lemur, *Eulemur collaris,* is the largest lemur species in this area. As of the year 2000, the fragments M3 and M4 (262 ha total) were the only two areas of Mandena still containing populations of this lemur species (see fig. 1). However, the pressure on these two fragments drastically increased with the newfound presence of charcoal makers in 1999 and 2000. Initial studies on M3 and M4 showed that the ecological condition of collared lemurs was no more viable and that the survival of the small remaining population was in jeopardy. The risk was considered so extreme that an immediate action plan was needed.

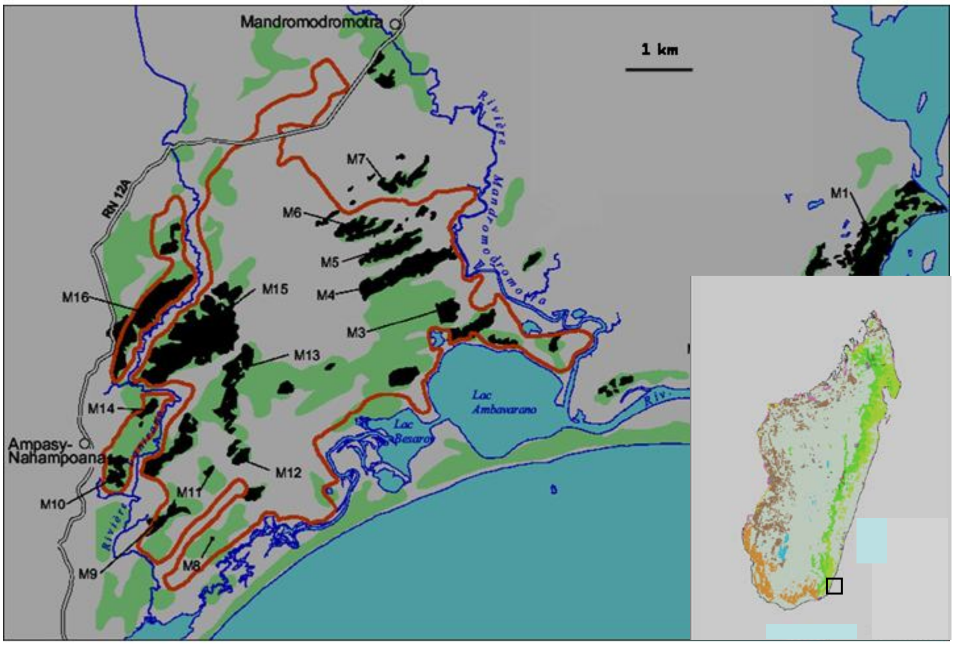

Fig. 1. Location of the study site. Light green: forest cover in 1950; dark green: forest cover in 2000. North is up.

Due to the unique circumstances in Mandena, translocation of the lemurs appeared to be the only reasonable option to maximise their chance of survival. Soorae & Baker (2002) define translocation as “the deliberate movement of wild primates from one natural habitat to another for the purpose of conservation or management”. However, translocation of primates is still a rare event, despite the growing number of experiments conducted with the New World monkeys (Strum, 2005). So far, only two previous experiments were carried out in Madagascar. In 1966 several Aye-ayes (*Daubentonia madagascariensis*) have been moved from the mainland to the island of Nosy Mangabe (Petter et al. 1977) and *Varecia variegata* born and raised in the USA have been released in Betampona (Britt et al. 1998). There are certainly several risks that must be considered when translocating a primate species. Poor environmental quality of the new habitat, stress and loss of social hierarchy caused by the displacement, competition with other animals that occupy a similar niche, post-release movement (e.g. homing behaviour), and failure of reproduction are among the main factors that were regarded when deciding on a place to which the groups could be translocated.

The forest fragments M15 and M16 were chosen in the end for various reasons. First of all, these fragments were within a new established conservation zone. Not only did this ensure protection from the impending mining project planned in the region, but it also provided an area in which hunting and habitat destruction by the locals could be managed and greatly reduced. Another major reason for the proposal of these fragments was, in fact, the absence of other *E. collaris* groups. Previous studies have shown that the act of translocation places a considerable amount of stress on primate populations, but a lack of competition between other individuals of the same species certainly reduces this tension (Berman & Li 2002). Indeed, the abundant presence of *E. collaris* in Sainte Luce, the less impacted littoral forest in the region, is one of the main reasons why the site was not chosen for the translocation. The M15 and M16 fragments, although already partially degraded themselves, were shown to have a similar forest structure and floral composition to those of M3 and M4. This was important to ensure the presence of certain plant species as food for the lemurs. Also, the main predators of *E. collaris*, namely the viverrid fossa (*Cryptoprocta ferox*), were absent from the fragments. This factor was essential because of the profound effects these predators can have on such a small population of lemurs. Lastly, the local communities were supposed to respond positively to the re-introduction of a species such as *E. collaris* which serves as a symbol for forest conservation and may improve eco-tourism projects.

In two separate translocation events in August 2000 and September 2001 the entire known population of *E. collaris* (28 individuals) in Mandena was moved from M3/M4 to M15/M16.

The overall goal of this project is to establish guidelines for the translocation of a lemur species, *E. collaris*, by analysing successes and pitfalls of this experiment and evaluating the ecological flexibility of this species to the new area. This research presents two aspects of great importance for lemur conservation. First, most of translocation operations carried out until today, included those with primates, did not follow a long-term post-monitoring agenda. Post-release monitoring is considered a vital part of any translocation or reintroduction project (Griffith et al., 1989). Thus, the Eulemur translocation in Mandena offers the rare opportunity of evaluating four years later the speed of re-adaptation of these prosimians to a new context. Second, since an intact littoral forest available for the translocated lemurs did not exist anymore in the region, we have the possibility of recording whether the Eulemurs may cope well with a degraded habitat and which strategies they use to achieve this adaptation.

In this context, I propose to investigate population dynamics, activity budget, feeding behaviour, home range and habitat utilisation of translocated *E. collaris* in the littoral forest of Mandena. However, it would be impossible to accurately evaluate how well the released animals did in their new home without indigenous animals for comparisons. Thus, the flexibility and potential adaptation of these groups in their new habitat will be tested and compared with data collected during my PhD research from non-translocated groups living in intact habitat (Ste Luce), which provide a "control".
In summary, I will try to answer to the following questions:

- Which kind of consequence on animal groups can be attributed to lemur translocation? Is it possible to re-construct group dynamics from data collected before and after the release?

- Are there different behavioural strategies in *Eulemur* groups living in partially degraded forest fragments as opposed to groups living in the intact littoral forest (group size, feeding behaviour, home range utilisation, inter- and intra-group interactions, etc.)?

Methods

Study Site and Species
This two-part study was conducted in the littoral forests of Mandena and Ste Luce near Fort Dauphin in south-eastern Madagascar. Data was first collected during my PhD in 2000 in a 377 ha fragment (S9) of the Ste Luce littoral forest (24°45'S 47°11'E), 50 km northeast of Fort Dauphin. Data for the second part of the study was collected in 2004 in the M15 and M16 fragments (230 ha) of the Mandena littoral forest (24°95'S

46°99’E), 12 km north of Fort Dauphin. Littoral forests on sandy soil are characteristically coastal at a maximum distance of 2-3 km from the sea and a maximum altitude of 40 m a.s.l. They have non-continuous canopies ranging from 6-12 m in height with emergent up to 20 m. Although overall vegetation is similar between Mandena and Ste Luce forest (Henderson 1999), human pressure has caused the Mandena fragments to be more degraded (QMM, 2001).

Eulemur collaris are cat-sized primates which live in multi-male and multi-female groups ranging from 2 to 17 individuals (Donati 2002).

Behavioural data

Daytime ethological data was collected on four *E.collaris* groups with similar size, three in Mandena and one in Ste Luce, during the months May-July and October-December (Tab. 1).

A total of 3 days per month was spent with each group. Each day of observation consisted of 12 consecutive hours of data collection from 6am to 6pm. Each day a different focal animal was chosen and followed by the researcher so that each adult individual per group was observed for an entire 12 hour period. Behavioural data was collected by an instantaneous sampling method with a 5 minute interval. Instantaneous data collected consisted of animal activity, food type, height, feeding and resting patches, number of animals in the tree, position in the tree, and position of resting, respectively. Behavioural categories included feeding, foraging, resting, moving, and social activities. Food types were noted as fruits, leaves, flowers, invertebrates, and other. The height of the animals was measured on two-meter intervals (i.e. 0-2, 2-4, 4-6, etc.).

	Mandena			**Ste Luce**
	Group A	**Group B**	**Group C**	**Group B**
Month/Year of observation	Oct-Dec 2004	May-Dec 2004	Oct-Nov 2004	May-Dec 2000
Adult females	1	2	1	1
Adult males	2	2	2	2
Sub-adults	1	1	0	1
Total	**4**	**5**	**3**	**4**

Tab.1. Site, month follows, and composition of each group

All feeding trees were marked with a flag and numbered to be found on a subsequent day. After behavioural data was collected, the observer returned to the trees with the help of an assistant to identify the species and to record dendrometric measures, i.e. diameter at breast height (DBH) and height. Additionally, the latitudinal and longitudinal coordinates of the feeding patches were recorded with a GPS and used to determine the group home range via the minimum convex polygon method. The Shannon index was used to determine the dietary diversity of each population.

Demographic data

The total Mandena population was censused once per year after the release. For this 20 people, spaced 10 m apart and equipped with walkie-talkies for communication, walked the whole forest of M15/M16. Surveys took one day. Group size was recorded and individuals were assigned to age-sex classes.

Captures and anatomical data

Animals were darted with a blowpipe using Ketanest for anaesthesia. They were weighed, measured and marked with coloured nylon collars. Mandena *Eulemur collaris* were measured in their original habitat (M3/M4) in 2000 and again four years after the translocation, 2004, into their new environment (M15/M16). Ste Luce Eulemurs were measured at the beginning of my PhD in 1999. Females were equipped with radio-collars for subsequent radio-tracking. Tissue samples were taken from all animals.

Nutritional analyses

Biochemical analyses were conducted at the Department of Animal Ecology and Conservation of the Hamburg University in 2001 (for Ste Luce samples) and 2005 (for Mandena samples). Food samples were weighed with an electronic balance (fresh weight), dried in an oven for a standard period, weighed again (dry weight), ground and dried again at 50-60°C before the analyses. The lipid content was determined by extraction using petroleum ether, followed by evaporation of the solvent. Soluble proteins were assessed by BioRad after extraction of the plant material with 0.1 N NaOH for 15 h at room temperature. Soluble carbohydrates and procyanidin (condensed) tannins were extracted with 50% methanol. Concentrations of soluble sugars were determined as the equivalent of galactose after acid hydrolisation of the 50% methanol extract. Samples were analysed for neutral (NDF) and acid (ADF) detergent fibres. NDF represents all the insoluble fibre (cellulose, hemicellulose and lignin), partly digestible in species with hindgut fermentation. ADF represents the fibre fraction containing cellulose and lignin, which are mostly indigestible for *Eulemur* spp. Polyphenolics concentration was estimated as Pyrogallic acid units.

The estimate of nutrient intake for primary and secondary compounds was obtained as the weighed average of dry matter per month and/or per phase, with the percentage of feeding time for each food item as the weighed coefficient (Conklin-Brittain et al. 1998).

Phenological data

To estimate variation in potential food availability, phenological data were recorded for the plant species (78 in Ste Luce and 58 in Mandena) known to have fruits consumed by the collared lemur. Trees were checked for the presence of ripe/unripe fruits twice a month (Bollen and Donati 2005; Randriashipara, unpublished data). As this lemur species relies mainly on fruits, I evaluated the difference in food availability between the two forests via the percentage of fruiting trees.

Seasonal variations in food availability included in collared lemur diet are shown in the phenological patterns of the two study sites (Fig. 2). The Mandena littoral forest exhibits a period of food scarcity during the first study period (May-July) and a window of relative resource availability during the second study period (Oct-Dec). The Ste Luce forest, by contrast, appears to have a relative resource availability in both periods. Overall, the percentage of fruiting trees remains consistently lower in Mandena, as expected for a degraded habitat.

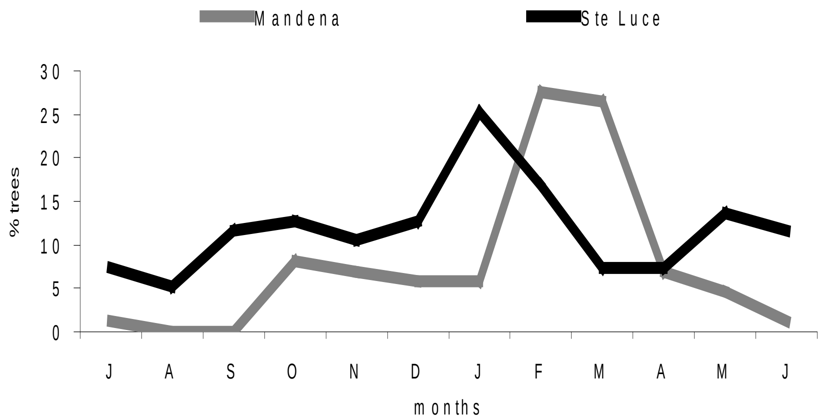

Fig. 2. Year-round fruit availability in the two study sites.

Statistics

To account separately for the differences between the two study sites, Mandena versus Ste Luce, the two study periods, food scarcity and food availability, and their interactions I used a two way ANOVA. For this data were arcsin transformed and then tested for normality and homoscedasticity. The Mann-Whitney nonparametric test was used to determine the significance of the differences between the two study sites.

Results

Demography of translocated groups

The post-monitoring census showed that, despite a slight initial mortality, the Mandena population has been increasing after the translocation to a maximum of 36 individuals in 2003 and then declined to 25 in 2004 (Fig. 3). In Mandena, the size of groups dropped after the translocation from a median of 4 animals to a median of 2.5 animals per group. The group size in Ste Luce is much higher with a median of 7 animals per group.

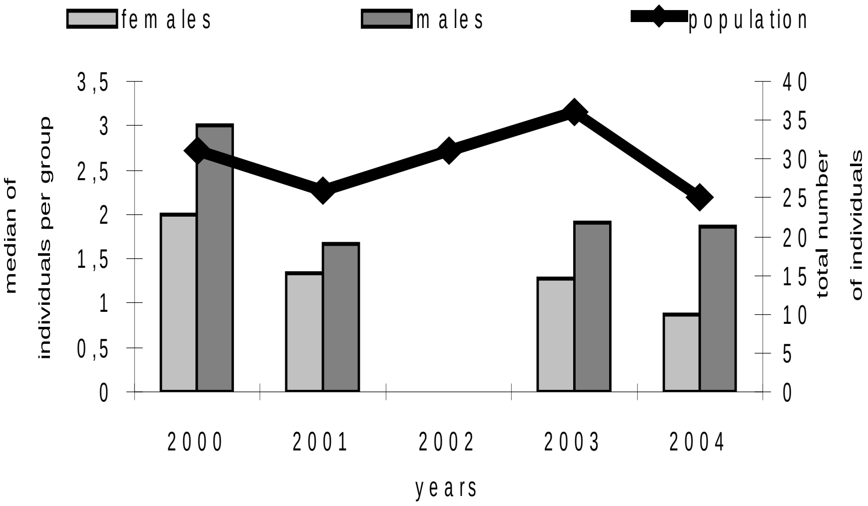

Fig. 3. Population characteristics of *E. collaris* after the translocation. Values are medians. No data were collected in 2002.

Animal health

As an indicator of the animals' health, the population's average body weight has been recorded for Mandena groups (either during translocation and four years later) and Ste Luce groups. In fact body weight of Mandena groups increased since the translocation from1.86 ± 0.19 kg (n=10) in 2000 to 2.15 ± 0.25 kg (n=11) in 2004. Thus, the Mandena Eulemurs had increased their body weight significantly by about 300 g (Mann-Whitney U test: $z = 2.45$, $n_1 = 10$, $n_2 = 11$, $p < .01$). On the contrary, the average body weight of Ste Luce "control" Eulemurs (2.18 ± 0.12 kg, n=7) did not significantly differ from the body weight of Mandena animals in 2004.

Animal time-budget

Overall, the Eulemur time-budget did not differ neither between translocated and non-translocated groups nor between study periods (Tab. 2). Both in Mandena and in Ste Luce the resting occupied most of the animal time (59.9%), followed by feeding (16.3%) and moving (13.5%). However, the non-translocated group foraged significantly more than the translocated groups (Site effect: $F = 8.63$, $df = 1$, $p < .05$).

	Mandena groups	**Ste Luce group**
Feeding	15.9	16.7
Foraging	1.2	4.6
Moving	13.9	13.2
Resting	61.1	58.5
Social	6.1	6.0
Other	1.3	1.1

Tab. 2. Time-budget of collared lemurs groups in Mandena and Ste Luce. Values are percentages of total records.

Animal feeding ecology
As expected, collared lemurs were mainly frugivorous (71,3%) during the study periods (Tab. 3). However, translocated groups spent significantly more time eating leaves (Site effect: $F = 17.53$, $df = 1$, $p <.01$). Fruits and invertebrates were eaten significantly more often during the period of food availability, i.e. October-December (Study period effect for fruits: $F = 10.36$, $df = 1$, $p <.05$; Study period effect for invertebrates: $F = 24.78$, $df = 1$, $p <.01$).

	Mandena groups	Ste Luce group
Fruits	65.8	76.8
Flowers	15.9	7.5
Leaves	10.2	7.5
Invertebrates	7.8	6.8
Other	0.2	1.4

Tab. 3. Time spent by collared lemurs eating on the main food categories at the two study sites. Values are percentages of total feeding records.

Neither the number of food species per month nor the dietary diversity differed significantly between sites and/or study periods (Tab. 4). Conversely, the translocated lemurs used a significantly higher number of feeding trees per day (Site effect: $F = 19.88$, $df = 1$, $p <.01$). Moreover, a significant interaction between site and study period was observed (Site x Study period effect: $F = 17.50$, $df = 1$, $p <.05$).

	Mandena groups	Ste Luce group
N. species in the diet	47	47
Dietary diversity	3.15	2.98
N. feeding patches	14.2 ± 3.6	9.4 ± 1.7

Tab. 4. Dietary diversity and number of feeding patches used in Mandena and Ste Luce by the collared lemurs.

Table 5 shows the intake of macronutrients (in gr per 100gr of food eaten) and polyphenolics (in units per 100gr) in the diet of Mandena and Ste Luce collared lemurs. Mandena lemurs ate significantly more fibres (Site effect for NDF: $F = 42.87$, $df = 1$, $p <<.01$; Site effect for ADF: $F = 29.48$, $df = 1$, $p <.01$) while Ste Luce animals had a great proportion of carbohydrates in their diet (Site effect: $F = 14.45$, $df = 1$, $p <.05$). At both sites collared lemurs ate more carbohydrates during the food scarcity period (Study period effect: $F = 19.45$, $df = 1$, $p <.05$) and more fibres and proteins during the period of food availability (Study period effect for NDF: $F = 39.73$, $df = 1$, $p <.01$; Study period effect for ADF: $F = 25.44$, $df = 1$, $p <.01$; Study period effect for proteins: $F = 9.71$, $df = 1$, $p <.05$). Also, a slightly significant interaction between site and study period was observed for carbohydrates (Site x Study period effect: $F = 8.74$, $df = 1$, $p <.05$).

	Mandena groups	Ste Luce group
Proteins	3.6 ± 0.7	3.9 ± 0.7
Carbohydrates	10.8 ± 2.9	19.8 ± 12.9
NDF	49.5 ± 4.2	34.8 ± 6.0
ADF	33.3 ± 4.5	25.7 ± 4.1
Polyphenolics	2.0 ± 0.9	2.6 ± 0.4

Tab. 5. Nutritional intake of collared lemurs at the two study sites. Values are percentages of dry matter.

Habitat Use
During the 6-month study period Mandena’s groups occupied an average home-range which was almost twice the size of the Ste Luce group (Tab. 6). The home-ranges of the three translocated groups in Mandena were not overlapping (Fig. 4), while in Ste Luce a 20% of overlap was observed (Donati, unpublished data). In Mandena the home-ranges of the three groups, though mostly centred in the forest, encompass large areas of swamp (Fig. 4). The analysis of the feeding trees size showed that Mandena groups fed on significantly

smaller plants, in terms of DBH, compared to Ste Luce group (Mann-Whitney U test: $z = 3.78$, $n_1 = 224$, $n_2 = 145$, $p < .01$), while there were no significant differences in height (Tab. 6).

	Mandena groups	Ste Luce group
Ranging area (ha)	38.5	20.5
DBH feeding patches (cm)	12.2 ± 10.4	21.9 ± 8.7
Height feeding patches (m)	7.9 ± 3.0	9.2 ± 3.0

Tab. 6 Ranging area and feeding patches characteristics in Mandena and in Ste Luce.

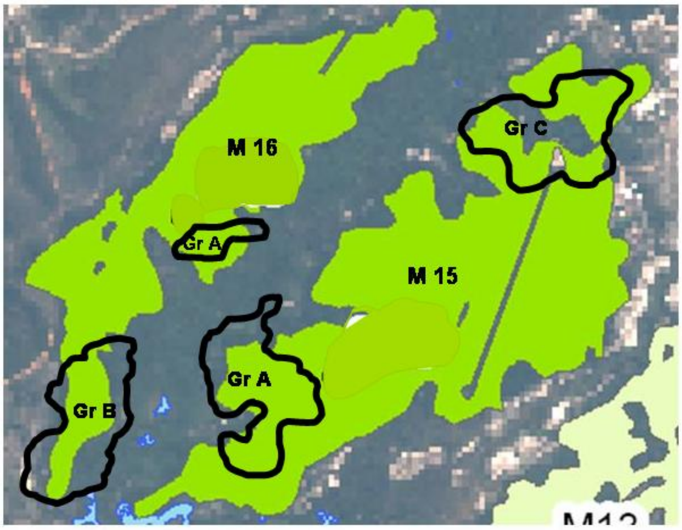

Fig. 4 Home-range distribution of the three groups studied over the M15/M16 fragments of Mandena forest. Light green: littoral forest; brown background: swamp area. The longest side of the figure corresponds to a length of 2 km. North is up.

Overall, the Mandena groups widely used different forest layers, while the collared lemurs in Ste Luce preferred forest layers between 4 and 8 meters from the ground (Fig. 5a). However, these differences in forest layer use were not significant between the two sites. Moreover, the average number of animals feeding on the same tree (party size) was lower in Mandena compared to Ste Luce (Fig. 5b). In Mandena I often saw just one individual feeding on a tree, while in Ste Luce more than 2 individuals and even the entire group was the rule. As a matter of fact, four lemurs eating on the same tree were observed significantly more frequently in Ste Luce than in Mandena (Mann-Whitney U test: $z = 2.01$, $n_1 = 6$, $n_2 = 6$, $p < 0.05$).

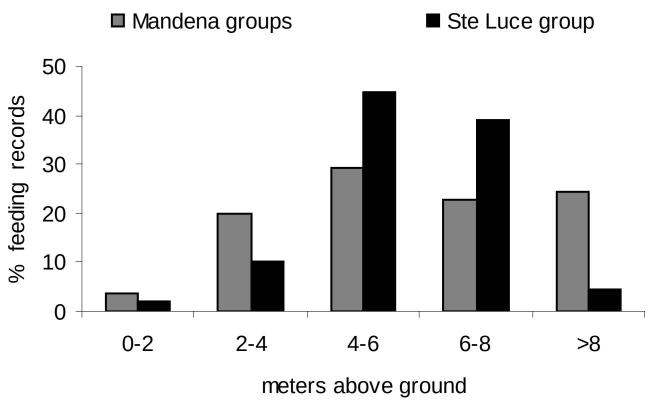

Fig. 5a. Time spent by the collared lemurs at different forest layers

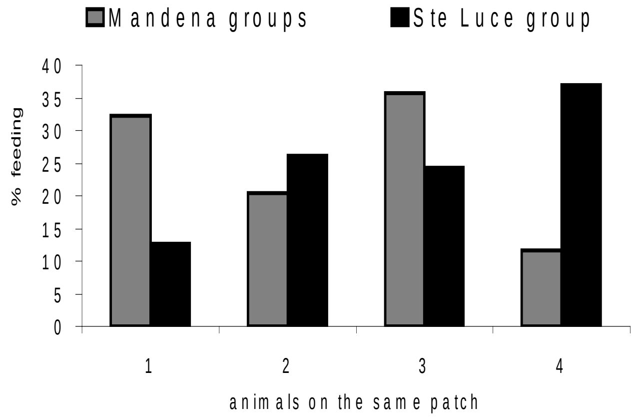

Fig. 5b. Time spent by a different number of animals (party size) eating on the same tree crown

Discussion

Overall, our data indicated that *Eulemur collaris* is a primate species able to cope with translocation movements. Except for a recent drop in size due to an unpredicted increase of predation, the lemur population had stabilised and has been growing during the years following the release. The good health of the animals is shown by two parameters. First, the translocated lemurs, caught in the original forest in a dramatic situation of malnutrition, gained an average of 15% of their body weight during the last years. As a consequence, the actual body weight of Mandena Eulemurs did not differ from that of the Ste Luce Eulemurs, the control group which lives in intact habitat. Second, the reproductive rate of translocated lemurs seems not to be different compared to other wild Eulemur populations. So, once the good animal health is ascertained, I can address to the question which problems the translocated lemurs had to face in Mandena and which strategies they have adopted to deal with them.

As discussed in the introduction, one of the major concerns in translocating the Eulemurs to the M15-M16 fragments was the degradation of the forest. Even if floristically and structurally the forest of M15-M16 is not very different from the intact littoral forest in Ste Luce (which in turn resembles the original animal habitat in M3-M4), the decades of wood exploitation Mandena was exposed to are likely to have changed the suitability of the habitat. In fact, our data indicated that in Mandena the collared lemurs had to cope with a number of disadvantages compared to the more natural condition faced by their conspecifics in Ste Luce. First, phenological comparisons showed that in the Mandena forest the availability of fruiting trees was lower than in Ste Luce, though the phenological profile was quite similar in both forests. Second, the Mandena’s Eulemurs had a lower quality diet than their conspecifics in the intact environment. The translocated lemurs relied much more on leaves, especially during the period of food scarcity, which resulted in a diet poorer in carbohydrates and richer in fibres. Third, collared lemurs had to feed on smaller feeding trees in Mandena compared to Ste Luce.

The first strategy used by translocated lemurs to cope with the new conditions was apparently a reduction of group size, which was actually less than half the value recorded for animals living in an intact habitat. Even if attention was paid to move and release the social units together, groups split up in smaller subgroups of two or three individuals immediately after the translocation. The data indicated that group fragmentation should be primarily interpreted as a strategy for more efficient foraging in a secondary forest even if initially it was probably a consequence of translocation. In fact, while animal relocation may normally cause a temporary collapse of social relationships within the groups, the presence of only small groups four year after the translocation suggests explanations other than the initial animal movement. So, the situation of partial degradation of the Mandena site seems to be the main reason for the observed very small group size, relatively to this species, of translocated groups. Since the feeding trees used by the lemurs were smaller in Mandena than in Ste Luce, only a few animals per group seemed to be able to feed on these resources, thus avoiding high intra-group competition. A tight prevention of feeding competition in Mandena is shown by the higher frequency in which a single animal fed on a tree compared to Ste Luce situation, where the whole group was often observed feeding on the same tree. It is possible that in this “socially relaxed” situation each individual may meet a high feeding rate which in turn may counterbalance the low quality of the Mandena diet. Unfortunately, I do not have data to confirm this hypothesis since the calculation of individual feeding rates was challenged by the poor observation quality of Mandena forest.

The larger areas used by Mandena groups compared to the Ste Luce animals can also be attributed to the differences between the two forests and not to translocation consequences. Recent studies show that exploration due to the new arrival into an area may only be evident in the first year post-translocation (Ostro et al. 1999). Our data indicated that the Mandena groups used a significantly larger number of feeding trees compared to their non-translocated conspecifics. This phenomenon is likely to be a consequence of the smaller feeding resources which characterises the Mandena area. The need of a large number of feeding trees may have caused an increase of the ranging area. The collared lemurs in Mandena not only appeared to range over extended areas of forest but they also used those in a wider spectrum. As a matter of fact, the Mandena lemurs showed a tendency to frequent every forest layer while in Ste Luce the animals seemed to be more specialised for the lower canopy. This result is of special concern for people willing to use translocation as a conservation tool and it highlights the importance of habitat quality. A ranging area almost twice the size of the natural condition and a lack of overlapping between home-ranges points out the fact that in Mandena lemurs need much larger areas than in Ste Luce. So, a precise analysis of the carrying capacity of a forest as compared to the original, possibly intact, animal habitat is necessary to judge where and how many animals to release.

Interestingly, in Mandena other socio-ecological parameters such as time-budget and dietary diversity appeared very similar to the values recorded for collared lemurs in intact habitat. So, apparently, in the degraded condition of Mandena the collared lemurs maintained a natural situation mainly by a reduction of group size and an increase of ranging.

Once having analysed habitat suitability and its importance to determine the strategies of translocated lemurs in their new area, I can now focus the attention on other outcomes caused by the operation. Our data indicated a sudden drop of lemur population size in 2004, mainly due to predation. During our study periods, lasting from May to December 2004, at least five animals doubtlessly have been killed by fossas (*Cryptoprocta ferox*), the Madagascar’s most powerful predator. At the time of translocation the fossa did not occur in Mandena and had not been reported before (QMM 2001). At the end of 2003 some of these animals were seen regularly in the forest. As Mandena is an isolated fragment of forest, this means that these forest-dwelling predators, surprisingly, have crossed several kilometres of savannah to get into the forest. Predation by even a small number of fossas could have a catastrophic effect on the recently translocated small population of lemurs (Britt et al. 2001), while the effect on a large population would have been comparatively small. In order to save the remaining collared lemurs from this threat a plan to capture the fossas recently immigrated in Mandena was elaborated. The details of this plan were drawn up after extensive discussions with international specialists. By the end of 2004 a total of seven fossas were caught, housed in temporary cages, and then, in summer 2005, released in a large area of forest some 30 km north of Mandena. This unpredicted problem highlights the importance of removing, or at least reducing, predation when a small population is planned to be moved. For this, as our experience showed, a long-term management is necessary since predators may invade the release area several years after the translocation.

Another problem encountered during this lemur translocation was the return of some groups towards their original site. This phenomenon is included among the post-release movements and may be recalled as homing behaviour. Homing has never been reported for primates but was hypothesised in translocated *Alouatta* (Richard-Hansen et al 2000). During the first year post-release a group of five animals crossed in two occasions the 3 km savannah separating M15-M16 from M3, the original fragment which was already burned down at that time. Lemurs were recaptured and brought back to the release fragment. Yet this experience emphasises the importance of a long-term post-monitoring of translocated populations to enhance the chance of animal survival.

A translocation is usually judged to be a success by the achievement of a self-sustaining population. However, more tolerant criteria to assess the success are the survival, the settlement within the pre-selected area, and the reproduction of translocated individuals (Richard-Hansen et al 2000). Given the rescue nature of our operation and the lack of alternatives for these lemurs in their original habitat, I think that the survival and healthy reproduction of the animals, achieved by the project up to now, is an important result. Of course the translocated population is far from being self-sustaining due to the small number of individuals moved. It is well known that the smaller a population is, the more likely the fitness will be compromised by losses of genetic diversity. However, the lemurs demonstrated to be adaptable to the new situation and the two main problems encountered during the operation, habitat suitability and predation, are likely to be managed by a long-term targeted intervention. Once these two problems are set apart and the population regains a growth, a re-stocking program to ensure the long-term genetic diversity of the Mandena population would probably be feasible. For this, genetic analyses to precisely define the taxonimic status of the Mandena collared lemurs and the neighbouring populations are in progress.

Changes on the Conservation Situation Improved by Rufford

Animal relocation is one of the many options available for to conservation biologists seeking to restore populations. They have the potential to attract considerable publicity and have the additional benefit of promoting conservation, raising public awareness, educating the public, and raising funds. As Mandena is a newly set up conservation area surrounded by several villages, one of the main concerns at the beginning of the operation was whether or not the protection of the forest would effectively work out.

The history of this translocation shows that the cause of previous extinction of collared lemurs from the M15-M16 fragments, hunting, was gradually reduced and finally stopped after the first months following the release. Even if at least two animals were killed by locals at the beginning of the operation, the program of information and education performed in the villages surrounding the conservation area proved to be effective. People realised and believed in the importance of reintroducing one of the symbols of their forest, the collared lemurs. Today, the conservation area of Mandena is managed by a committee, called COGE, which includes the two villages of Mandrmodomotra and Ampashy as well as members of the Ministere des Eaux et Foret and QMM (QIT Madagascar Minerals). The COGE organises a patrolling of the forest and manages the incomes entering from a number of activities such as ecotourism and bees keeping. Since the beginning of the translocation two Malagasy students have completed their diploma thesis on diverse aspects of this lemur translocation, both strictly collaborating with me. Moreover, together with me and the students, the animals were captured, habituated and followed by a group of motivated assistants, all coming from the surrounding villages. The help of these people, some of them previously hunters, was invaluable in tracking the animals in the forest. The drop of human pressure on the forest, included the wood exploitation, has greatly facilitated the observation of the lemur groups which, in turn, gave the ground to develop eco-touristic activities in Mandena.

Being the main funding resource for this project the Rufford grant was a fundamental help to outline the result achieved by this first experiment of translocation in the littoral forest. Our data showed the importance of a long-term monitoring agenda to assess the success of a lemur population movement. The initial settlement of animals does not signify the success of an operation. Factors such as habitat suitability and predation need a continuous management over the years and periodic control of the population health. On the top of all, together with the scientific results, the Rufford grant allowed a Malagasy student and local assistants to be funded. This resulted in a staff work which allowed exchange of competences, knowledges, and conservation concerns. Today, Mandena is not just a conservation area but it is managed by local people who know the importance of lemurs for the forest and for their own interests. The Rufford fund provided a tool to spread conservation awareness in the region.

Challenge, Solution Adopted and Changes Raised During the Year

I encountered a number of problems to carry out the present project, which in some cases delayed or changed my plans. First of all, one of the questions I wanted to answer in my initial project was proved to be unrealistic. I wanted to verify whether there exist any significant differences in the regeneration of plant species dispersed by *E. collaris* among the forest fragments where this lemur still survives and those where it already disappeared. However, it was very difficult and in most case impossible to recognise the young phases of the littoral forest trees. Moreover, the diverse floristic and structural composition of the remaining forest fragments implied a number of confounding variables other than the mere presence/absence of Eulemurs. Thus, this part of the project was discarded while more time was dedicated to the collection of behavioural data.

Another question initially formulated in the project, as to how *E. collaris* make use of the surrounding exotic plantations, could not be investigated. None of the groups followed in Mandena frequented the exotic plantations during the study periods but they just exploited the forest and the swamp areas.

A number of reasons delayed the work in the field. By far, the most important problem encountered during the observations was the condition of the terrain. As described in the results, translocated lemurs spent a large part of their daytime activities in the swamp areas. It was particularly difficult, often dangerous and sometimes impossible to follow the lemur groups in this part of their home-ranges. Falling in deep mud bottoms and encountering local crocodiles were a daily threat. Also, from May to July we had a peak of rain which caused an inundation of the forest and turned the work in Mandena into a very hazardous task.

Once back at home, delays were also accumulated during the analyses of the data. Since this was staff work it was necessary to join the data collected by me, the Malagasy student I worked with and our local assistants. Given the communication problems between Italy and Madagascar and a number of personal problems, in particular, this process took a while.

Expenditure Vs Budget

This project was originally planned to last two years and to include four missions to Madagascar. However, the two research proposals presented to the Italian Ministry of Research and the University of Pisa (a two year post-doc and an inter-university program) failed to be granted. Thus, the data on the field were limited to only two missions which were planned to be funded by the Rufford grant. Since this alternative plan was considered from the beginning due to the unpredictability of conservation funding, I made the effort of trying to answer the major questions of my project in half of the time. This was achieved by organising the two missions in the field during two delicate and opposite periods of the year, as explained in the methods, and by the help of a number of field assistants.

As planned, the expenditures for the two missions in Madagascar were mostly covered by Rufford (please, see my original Rufford application for expenditure details). However, two expenditure voices turned out to be much more expensive than predicted. These were the costs for the Malagasy student work (salary, logistics, accommodation, etc.) and the costs for my own accommodation in Fort Dauphin. The reason for this was the change of the collaboration agreement between the Malagasy government, QMM (which provided the logistics there) and the researchers willing to work in this agreement. In particular, since 2004 QMM does not provide any more a free accommodation in Fort Dauphin. The consequent hotel fees I had to pay for me and the student during the stay in Fort Dauphin increased my overall expenditures. Nevertheless, in summer 2004 (between the first and the second mission) I applied for a small grant from QMM for the translocation project. My grant application was successful and the money I got was enough to cover the surplus expenditures.

Acknowledgements

This work was carried out under the Accord de collaboration between the Department of Animal Biology and Anthropology of the University of Antananarivo, the Institute of Zoology of Hamburg University and QIT Madagascar Minerals (QMM). I thank the Commission Tripartite of the Malagasy Government, the Ministère des Eaux et Forets, QMM and Missouri Botanical Garden at Antananarivo for their collaboration and permissions to work in Madagascar. I thank Joerg Ganzhorn and Silvana M. Borgognini-Tarli for their continuous scientific support during the research. I acknowledge Jean Baptiste Ramanamanjato, Manon Vincelette, Laurent Randrihasipara, Johny Rabenantoandro and Faly Randriatafika of the QMM Environmental Team for providing help at various stages of this research in Madagascar. I'm grateful to Adam Britt for his help during the captures and to An Bollen, Nicoletta Baldi, Valentina Morelli and Stacey Schmidt for providing additional data on *E. collaris* feeding ecology. A very important thanks goes to Kelard Ndremifidy, who worked with me with invaluable motivation and passion. Special thanks for the technical assistants of the QMM fauna staff in Mandena and Ste Luce. In particular I thank Kadoffe, Philemon, Ramisy, Sebastien, Craissant and Roger. I was supported by a doctoral grant from the Italian Ministry for Scientific Research (MURST) and the University of Pisa during 2000, by a Rufford Small Grant and a QMM grant during 2004.

References

Berman, C.M., Li J.-H. 2002. Impact of translocation, provisioning and range restriction on a group of *Macaca thibetana*. Int. J. Primatol., 23(2): 383-397.

Bollen, A., Donati G. 2005. Phenology of the littoral forest of Sainte Luce, South-eastern Madagascar. Biotropica, 37(1): 32-43.

Britt, A., Welch, C.R.; Katz, A.S. 1998. First release of captive-bred lemurs into their natural habitat. Lemur News 3: 8-11.

Britt, A., Welch, C.R., Katz, A.S. 2001. The impact of *Criptocropta ferox* on the *Varecia variegata variegata* reinforcement project at Betampona. Lemur News, 6: 35-37.

Conklin-Brittain N.L., Wrangham R.W., Hunt K.D. 1998. Dietary response of Chimpanzees and Cercopithecines to seasonal variation in fruit abundance. II. Macronutrients. Int. J. Primatol 19(6): 971-998

Donati, G. 2002. *Activity pattern of* Eulemur fulvus collaris *in relation to environmental variations*. PhD thesis, Pisa University.

Griffith, B., Scott, J.M., Carpenter, J.W., Reed, C. 1989. Translocation as a species conservation tool: status and strategy. Science, 245: 477-480.

Henderson, S. 1999. *Relationships between structure and composition in the littoral forest of southeast Madagascar*. Unpublished Master Thesis, Oxford University.

Ostro L.E.T., Silver S.C., Koontz F.W., Young T.P., Horwick R.H.1999. Ranging behaviour of translocated and established groups of black howler monkeys *Alouatta pigra* in Belize, Central America. Biol. Conserv. 87: 181-190.

Petter J.J., Albignac R., Rumpler Y. 1977. Faune de Madagascar: Mammifères Lémuriens. Volume 44, OSTOM CNRS, Paris.

QMM (QIT Madagascar Minerals S.A.) 2001. *Projet ilménite: Etude d'impact social et environmental*. Unpublished Report. QMM, Antananarivo, Madagascar.

Richard-Hansen C., Vié J.-C., de Thoisy B. 2000. Translocation of red howler monkeys (*Alouatta seniculus*) in French Guiana. Biol. Conserv. 93: 247-253.

Soorae P.S., Baker A. 2002. Guidelines for Nonhuman Primate Re-introductions. IUCN/SSC Re-introduction Specialist Group.

Strum S.C. 2005. Measuring success in primate translocation: A baboon case study. Am. J. Primatol., 65: 117-140.