Chapter 4.9
Translocation as a Conservation Measure for an Endangered Species in the Littoral Forest of Southeastern Madagascar: The Case of *Eulemur collaris*

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Abstract

During the last decades, various primate species around the world have been translocated from their threatened native habitats into new protected areas. Lemur populations living in the littoral forests of southeastern Madagascar are isolated in small forest fragments and are threatened by human pressures on this habitat. To avoid extinction of a remnant population of *Eulemur collaris* living in a forest fragment destroyed by charcoal makers, 28 individuals were transferred into a new protected area of approximately 230 ha within the Mandena Forest (M15/M16) in 2000 and 2001. Three groups of *E. collaris* were followed systematically for four years after their release at the new site. The size and composition of the translocated groups were monitored each year. After an initial phase of instability and death of several animals, the population increased to 36 individuals. Birth rates were similar to those of non-translocated groups living in largely undisturbed habitat. During the four years, animals gained weight. After translocation, the original groups split up in subunits consisting of one adult female and one or two adult males. Subsequently, several *Cryptoprocta ferox*, the largest living Carnivora on Madagascar, moved into the area, where they were previously unknown. They predated heavily on the translocated *E. collaris* and threaten the persistence of this population. The results show that *E. collaris* can be translocated successfully, however, translocation activities need continuous monitoring and possibly additional management.

Résumé

Le translocation à titre de mesure de conservation pour une espèce en danger dans la forêt littorale du sud-est de Madagascar: le cas d'*Eulemur collaris*. Au cours des dernières décennies, plusieurs populations d'espèces de primates du monde ont été transférées de leur habitat naturel menacé dans de nouvelles aires protégées. Les populations de lémuriens vivant dans les forêts littorales du sud-est de Madagascar sont isolées dans de petits fragments forestiers et sont menacées par la pression humaine exercée sur cet habitat. Afin d'éviter l'extinction d'une dernière population d'*Eulemur collaris* vivant dans un fragment forestier détruit par les bûcherons produisant du charbon de bois, 28 individus ont été transférés dans une nouvelle aire protégée d'une superficie de l'ordre de 230ha ((fragment M15/M16) en 2000 et en 2001. Trois groupes d'*E.collaris* ont été systématiquement suivis pendant quatre ans après avoir été relâchés dans le nouveau site, après quoi la taille et la composition des groupes transférés ont encore été suivies chaque année. Après une première phase d'instabilité et de mort de plusieurs animaux, la population a augmenté pour atteindre 36 individus. Les taux de natalité étaient similaires à ceux de groupes non transférés qui vivaient dans des habitats relativement intacts. Au cours des quatre années, les animaux avaient pris du poids. Après transfert, les groupes d'origine ont éclaté en sous-unités comprenant une femelle adulte et un ou deux mâle(s) adulte(s). Ultérieurement, plusieurs *Cryptoprocta ferox*, le plus grand carnivore actuel de Madagascar, ont atteint la zone de laquelle ils n'étaient pas connus préalablement. Ils ont représenté des prédateurs importants pour les *E. collaris* transférés jusqu'à menacer la survie de cette population. Les résultats montrent que *E. collaris* peut être transféré avec succès mais que des

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activités de transfert *in situ* doivent s'accompagner d'un suivi continu et, le cas échéant, de mesures adéquates en matière de gestion.

Introduction

The forests around Tolagnaro are under substantial pressure to meet the daily needs of the local human population (Bollen and Donati 2006, Vincelette *et al*. Chapter 2.4). Hunting also threatens the survival of *Eulemur collaris*, the largest lemur species of the humid littoral forests of southeast Madagascar. In 1999, the species remained in only one of the forest fragments of Mandena, M3 (≈220 ha at the time) with occasional excursions of the animals into the nearby fragment M4 (≈40 ha). A few years earlier this species still occurred in M15/M16 (together ≈230 ha) and M20 (≈40 ha), but by 1999 they had been hunted-out. Between 1995 and 2000, immigrant charcoal makers from the nearby town of Tolagnaro reduced and degraded M3 and M4 threatening the existence of the remaining *E. collaris* population.

In 1999, QIT Madagascar Minerals (QMM) initiated a scientific discussion with biologists and institutions to find a solution that would prevent the further decline of the last population of *E. collaris* at Mandena. Several conservation measures were put in place, including a ban by local authorities on cutting and confiscating wood. However, these measures did not curb the degradation and destruction process. Finally, it was decided to move the remaining animals from M3 and M4 to M15/M16, which, in the meantime, had been transferred into an effectively protected area (Fig. 1).

Translocations (or re-locations) are defined as moving individuals or populations from one area to another within their original distribution (Soorae and Baker 2002). This is a common conservation option, but has rarely been applied to lemurs. In 1966, several *Daubentonia madagascariensis* were captured on the mainland and moved to the Réserve Spéciale de

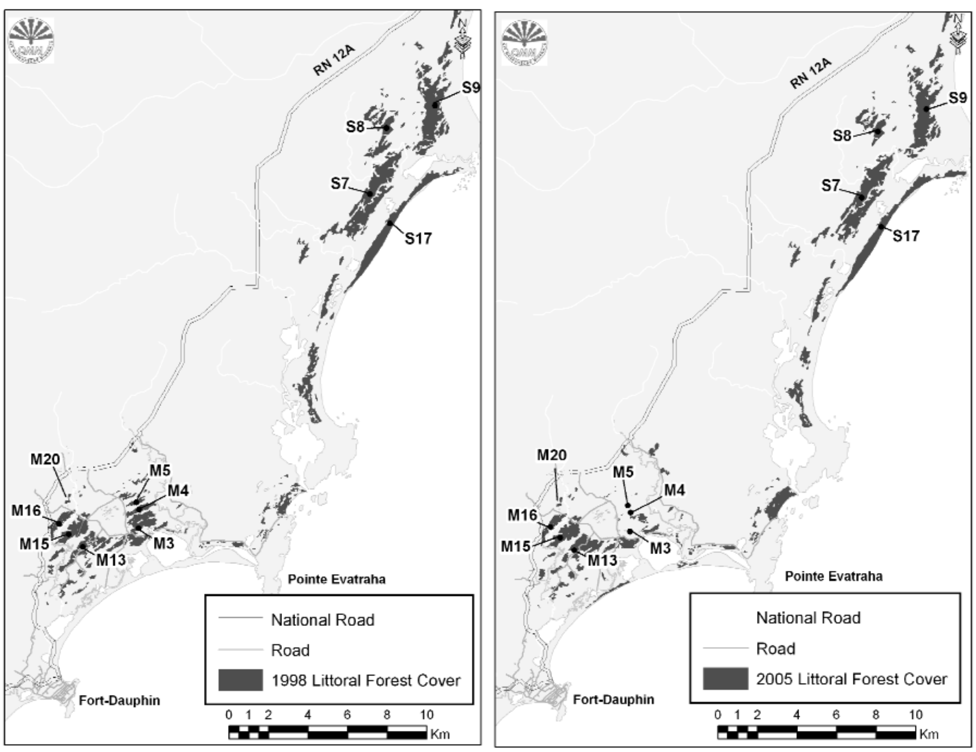

Figure 1. Location of sites and extent of littoral forest reduction between 1998 and 2005.

Nosy Mangabe (Petter *et al.* 1977). In a slightly different procedure, *Varecia variegata*, born and raised in zoological parks in the United States, were transported to Madagascar and released in the Réserve Naturelle Intégrale (RNI) de Betampona (Britt *et al.* 1998, 2000). These and other translocations or reintroductions of primates have had varying degrees of success (Griffith *et al.* 1989, Strum 2005). Often social relationships and group cohesion suffer in relocated groups, birth rates drop, and infant mortality increases (Johnson and Southwick 1984, Berman and Li 2002). In order to be effective, the original threats have to be removed or greatly reduced, the quality of the habitat has to be appropriate, and competition must be reduced (for a review see Fischer and Lindenmayer 2000). This requires an appropriate management plan for the operation and integration of the local human population.

Taxonomically, *Eulemur collaris* is part of the *E. fulvus* group. This group, for some time considered a single species, has an extraordinary ecological flexibility with diets ranging from consisting almost exclusively of leaves, to almost exclusively of fruits, to nectar, and even animal matter (Overdorff 1993). This plasticity allows them to live in almost every forest type on Madagascar (Mittermeier *et al.* 2006). Parallel studies in the littoral forest of Sainte Luce, some 20 km north of Mandena, showed rather opportunistic feeding behavior in this species (Donati 2002, Bollen *et al.* 2005). These results suggested that *E. collaris* had a high probability of successfully adapting to a new area after translocation. Therefore, and given the immediate threat of extirpation of the Mandena population, the decision was made to re-locate the remaining animals from M3 to M15/M16.

In this chapter, we describe the different phases of the translocation, and the response of the animals. The groups had been observed in their original habitat prior to the translocation. We then describe the translocation in August 2000 and October 2001, the population dynamics of the translocated groups in their new forest fragment over the next four years, and the problems encountered during this time. We also evaluate whether translocation is a viable option for urgent conservation measures to protect lemurs of the littoral forests.

Methods

Choice of sites for the translocation

Conservation status

M15/M16 was chosen for the translocation. These forests are part of the Mandena conservation zone, which is managed by the communes of Mandromondromotra and Ampasy in collaboration with the Service de la Direction des Eaux et Forêts and QMM (see Vincelette *et al*. Chapter 2.4, Rarivoson Chapter 6.1). The local villagers responded positively to the re-introduction of a species such as *E. collaris*, which serves as a symbol for forest conservation. The management plan for the conservation zone prohibits hunting and woodcutting. Furthermore, the Ecological Research Station of QMM and the staff in the forest were considered helpful to provide a permanent presence and emplement the management plan. Hunting was considered the main reason for the extinction of the original population of *E. collaris* in M15/M16 prior to the creation of a conservation zone and subsequent translocation. Even though the forests of Mandena are degraded, this site was chosen over the more intact habitat at Sainte Luce because lemur densities at the latter site seemed rather elevated (Donati 2002). In addition, it was unknown whether the populations of Mandena and Sainte Luce differed genetically. Finally, M15/M16 was considered a suitable site because *E. collaris* were known to occupy the site previously. M15/M16 is about 3 km west of M3 and M4 (Fig. 1).

Size and habitat heterogeneity.

The littoral forest fragments of M15/M16 are separated by a swamp forest, and even though they have structural differences the latter is used by the animals as a bridge providing a continuous distribution between these two fragments. The area available to the animals was 230 ha (160 ha of littoral forest and 70 ha of swamp forest). In total, 28 individuals were translocated into M15/M16, resulting in a density of 12 individuals per km^2. This is well below the density of 38 ind/km^2 found in Sainte Luce (Donati 2002). However, comparisons between the two forests are difficult since Mandena presents a slightly different floristic composition, and a higher degree of degradation than Sainte Luce.

Food availability

The floristic composition and forest structure of M15/M16 are similar to those of M3 and M4 (Ralison and Razanahoera 2006, Rabenantoandro *et al*. Chapter 3.1, Ganzhorn *et al*. Chapter 4.8). The phenology of trees in Mandena also seemed similar to that of Sainte Luce (Bollen and Donati 2005).

Predation

Cryptoprocta ferox, the largest living Carnivora on Madagascar, which is known in Malagasy as *fossa*, is an important predator of *Eulemur* spp. (Goodman 2003, Hawkins 2003). This animal had not been reported in Mandena, but there were previous records of its existence in Sainte Luce (Lewis Environmental Consultants 1992). Given the intensity of *fossa* predation on introduced individuals of *Varecia variegata* in the RNI de Betampona, an eastern rainforest site (Britt *et al.* 2001), the absence of the predator was considered an advantage.

Intra-specific competition

The *Eulemur collaris* population of M15/M16 had been reduced by hunting to a single couple in 1998 (Ralison 2001). Thus, intra-specific competition between the incumbent residents and the introduced animals seemed negligible.

Translocation: August 2000

Prior to translocation, the groups of *Eulemur collaris* in M3 were subjects of a behavioral study combined with an investigation on human pressures on the fragment. These data were complemented by information collected in 1998 on group characteristics, home ranges, and the ecology of the groups to be translocated (Ralison 2001, Rasolofoharivelo 2001). Starting on 19 August 2000, *E. collaris* in M3 and M4 were captured and transferred to M15/M16. This was a joint effort by QMM, the Madagascar Fauna Group, and students of the universities of Pisa and Antwerp. The team also included representatives from ANGAP (Association Nationale pour la Gestion des Aires Protégées), the Ministère des Eaux et Forêts, and WWF. All three known groups in M3 and M4 were captured, a total of 18 animals (8 females, 10 males, Table 1).

Animals were darted with a blowpipe, and Ketanest was used for anesthesia. They were weighed, measured, and marked with colored nylon collars. Measurements follow Glander *et al*. (1992). Several females were equipped with radio-collars for later tracking. Tissue samples were taken from all animals for subsequent molecular studies.

Animals were transported to M15/M16 by car. There, the three groups were housed separately in habituation cages, two of which were built in the forest of M15, and one in M16. For three weeks, the animals were cared for day and night. They were fed fruits, flowers, and leaves known to be part of their natural diet at that particular time of the year. The diet included domestic market fruits to familiarize the animals with this type of food in case supplementary feeding was necessary.

The animals were released on 20 September 2000. This date was chosen because *Uapaca littoralis*, a very important food source for *Eulemur collaris* (Donati 2002), began fruiting and food availability was favorable at this time of the year. Natural food availability increases further with the beginning of the wet season in November/December (Bollen and Donati 2005, Donati *et al*. 2007). Commercial fruits were offered at certain sites, especially after the birth of infants at the end of September and beginning of October.

Translocation: September 2001

A second translocation from M3 and M4 to M15/M16 was carried out in September 2001 (Table 1). This was necessary to move the remaining animals, which had not been trapped in 2000. In addition, six animals translocated in 2000 had returned to M3. These six and another 10 animals (5 females, 11 males) were caught and translocated in 2001. Thus, in total, 28 individuals were translocated from M3 and M4 to M15/M16. This seems to have been the total population of M3 and M4 at the time.

The second translocation resulted in very dynamic fission-fusion activities betweeen the newly arrived animals and the groups from the first release. Since only a few animals were equipped with radio collars and some had lost their collars, it was very difficult to track group composition change over time.

Systematic follows

Three groups of *E. collaris* comprising 9 – 13 individuals were followed systematically at least three days per week from the time of their release to

December 2004. Follows were from dawn to dusk. Birth and mortality rates presented herein are based on these three groups, which represent 46% of relocated individuals.

Population census

The total population was censused once per year. For this exercise, 20 people spaced at 10m intervals spanning the width of the M15/M16 forest, and equipped with walkie-talkies for communication, walked the entire length of the forest. Surveys usually took one day. Observed animals were sexed and assigned to age classes. Differences between males and females were easy to detect due to the sexual dichromatism present in all *Eulemur* spp. Infants were defined as animals still dependent on their mother to move and/or forage.

Results

Group characteristics

Immediately after the release, the groups traveled the complete length of the natural forest within the fragments. During the first months after the release, fission/fusion of groups was frequent and resulted in subgroups of 2-3 animals. Most of the groups consisted of one female and two males. Movements between the three original groups were mostly due to surplus males. In early 2001, one group had returned to M3, which would have required crossing of 3 km of open habitat (heath savannah). At the end of the second translocation in 2001, 28 animals were living in M15/M16 (Table 1). The median size of groups declined after the translocation from 4.0 animals to 2.5 animals per group (Table 2). Though the number of males per group had a tendency to decrease (Mann-Whitney U test: $z = 1.84$, $p = 0.06$), none of the group characteristics differed significantly between 2000 (before the translocation) and 2001 (after the translocation, Table 2).

The number of animals had increased to 36 by 2003. In November 2004, after the appearance of several *Cryptoprocta*, the number declined to 25 (Table 1). Also by November 2004, two groups had left the conservation zone and were found in M20, a small fragment of approximately 40 ha north of M16, but linked to it by *Eucalyptus* plantations and a stand of *Melaleuca*. A couple was found in a small forest called "*ala mafotra*," which is also north of the conservation zone.

Biometric measurements

Various biometric measurements of adult *Eulemur collaris* were taken before their translocation and again four years later. As males and females did not show sexual dimorphism in size, data from the different individuals were pooled. None of the morphological measures differed between years, but the animals had increased their body mass significantly by about 300 g between the years 2000 to 2004 (Mann-Whitney U test: $z = 2.45$, $p = 0.01$; Table 3).

Birth rates and mortality

Five individuals were born after the first translocation in 2000 while the animals were still in the habituation cages, and one of them subsequently died. On 28 September 2000, one pregnant female was killed, probably by villagers, indicating that the protection of the conservation zone was not adequate at that time. On 18 November 2000, an adult female accompanied by two infants was predated upon probably by the Madagascar Harrier Hawk *Polyboroides radiatus*, the largest living bird of prey of Madagascar. The infants were not seen again afterwards. Another female with an infant was killed by a villager in January 2001. This incident took place at the southern end of M16 where the conservation zone borders the village of Ampasy. It is possible that the lemur group had ventured into the village fruit trees. The infant of this female also disappeared. One male was found dead in the M15 swamp. He had wounds on his back, which could be due to an attack by a predator. Three other males disappeared in 2001. Thus, one year after the first translocation, five infants had been born, and three infants and seven adults had died or disappeared (4 males and 3 females). The first reports of *Cryptoprocta* in the conservation zone came at the end of 2003. Between June and December 2004, four female *E. collaris* were killed by *Cryptoprocta*. Tooth marks were found on the radio-collars of these lemurs, which left little doubt to the cause of their death.

Birth rates and mortality were calculated more accurately for the three groups (9-13 individuals) observed continuously after their release (Table 4). Birth rates were defined as the number of infants per number of adult females. Mortality was calculated as the number of adults that died per total number of adults. Birth rate was, on average, 79.1% with a minimum of 33.0% in 2002. Infant mortality was, on average, 50%. No infants were born in 2001. Adults died in 2000 and 2001, and again in 2004. The average annual mortality was 14%.

Discussion

Four years after the translocation of 28 individuals of *Eulemur collaris*, their population appears to have increased and stabilized. Immediately after the translocation, group size declined and groups split into smaller subgroups of two or three individuals (Ravoangy 2004). In Mandena, groups became smaller due to the emigration of males rather than females. A similar phenomenon has been observed in other studies (Overdorff *et al.* 1999). The reduction of group size after translocation has been interpreted as a consequence of altered or missing hierarchical dominance structures (Yeager and Silver 1999). Another interpretation is that larger groups split into smaller units to adapt to the availability of resources. Patch size (measured as tree size) in the relatively undisturbed forest of Sainte Luce, and probably also in M3 prior to its destruction, was larger than that in M15/M16 (Henderson 1999, Ralison 2001, G. Donati, unpubl. data). Reducing group size in response to small patches of resources reduces intra-group competition. This phenomenon is known from many studies on lemurs and other primates (Ganzhorn 1988, van Hooff and van Schaik 1992, Barton *et al*. 1996).

Fission of groups in degraded forests would then be a consequence of resource size rather than a consequence of the breakdown of dominance structures. Since the animals gained weight post translocation, however, food availability seems sufficient, and actually might have been higher in M15/M16 than in M3 and M4 at the time of capture. Furthermore, the birth rates after translocation were similar to those in the relatively undisturbed forest of Sainte Luce (Donati 2002), and match birth rates and infant mortality rates of *E. rufus* in the Parc National de Ranomafana (birth rates: 45%, infant mortality: 35%, Wright 1992, Overdorff *et al.* 1999). Thus, reduced food availability might be not responsible for the reductions of group size, even though *Eulemur* spp. adapt their group size to the size of food resources (Ganzhorn 1988). The groups of the population translocated to M15/M16 were markedly smaller than those in M3, both prior to translocation

Table 1. Population characteristics of *Eulemur collaris* before (M3 and M4) and after (M15/M16) translocation in the Mandena Forest.

	Inventory M3 and M4 July 2000	Captures M3 August 2000	Inventory M15/M16 September 2000	Captures M3 and M4 September 2001	Inventory M15/M16 November 2001	Inventory M15/M16 November 2003	Inventory M15/M16 November 2004
Females	12	8	8	5	8	11	7
Males	19	10	10	11	15	20	15
Infants	-	-	5	-	3	5	3
Groups	6	3	6	5	9	11	8
Total animals	31	18	23	16*	26	36	25

*Six of the 16 individuals had already been caught in 2000.

Table 2. Size and composition of *Eulemur collaris* groups before and after translocation in the Mandena Forest. Values are medians and ranges.

	Before translocation		After translocation	
	1998	2000	2001	2004
No of groups	n=3	n=6	n=6	n=11
Ind./group	8.0 (6-8)	4.0 (2-8)	2.5 (2-5)	3.0 (1-6)
Females/group	3.0 (3-3)	1.5 (1-4)	1.0 (0-3)	1.0 (0-3)
Males/group	5.0 (3-5)	3.0 (1-5)	2.0 (1-2)	2.0 (1-3)
Sex ratio	1.4	1.5	1.3	1.5

Table 3. Body weight and body measurements of adult *Eulemur collaris* before (2000) and after (2004) translocation in the Mandena Forest. Values are means ± standard deviation (cm), except for body mass (g).

	M3 and M4 2000 N=10	M15/M16 2004 N=11
Body mass	1861 ± 190	2150 ± 254
Canine length	0.9 ± 0.1	0.9 ± 0.1
Head-body length	45.4 ± 2.8	46.1 ± 2.6
Tail length	50.1 ± 3.0	50.3 ± 1.0
Tibia	13.9 ± 1.0	14.2 ± 0.6
Femur	13.5 ± 0.9	14.0 ± 0.7
Humerus	9.0 ± 0.6	9.3 ± 0.9
Radius	10.1 ± 0.4	9.9 ± 0.6
Foot	9.7 ± 0.5	9.5 ± 0.4
Hand	6.5 ± 0.4	6.5 ± 0.7

and in Sainte Luce. Interestingly, in the groups with more than one adult male, the surplus males always have to wait their turn far from the feeding trees, and often they do not eat during these feeding bouts. Also, aggression between males seemed very high as compared to the Sainte Luce population, and might have driven some males away from the group to range solitarily (Day and Randria 2006). It is still an open question whether these features are a consequence of low food availability in general, smaller sizes of food patches in Mandena than in Sainte Luce, or a yet undetected consequence of the translocation (G. Donati, unpubl. data).

Incidentally, the increase in infant mortality might be a consequence of the reduction of group size. Due to the size effect, small groups might suffer higher predation pressure than larger groups. Predation pressure is hard to quantify, but the various incidences of attacks and predation by *Polyboroides radiatus* and other predators indicate that predation is important. Possibly as a response to the pressure from aerial predators, the animals spent most of their resting time in the swamp forest where they had more protection from aerial predators than in the littoral forest. In fact, in this area, swamp forests are characterized by a continuous and very dense canopy layer constituted by small trees. Moreover, because of forest degradation, fruiting trees often emerge above the general forest canopy, exposing feeding animals to attack by birds of prey.

At the time of translocation, *Cryptoprocta ferox* was unknown in Mandena (Lewis Environmental Consultants 1992, QMM 2001). By the end of 2003, some of these animals had been seen regularly in the forest. At least four female *E. collaris* were killed by *C. ferox* between June and October 2004. The disappearance of several other *E. collaris* indicates that predation pressure was probably much higher. The animals killed did not show any signs of malnutrition. For the time being, *Cryptoprocta* represents the most important threat to the success of the translocation, which is in direct parallel to the re-introduction program of *Varecia variegata* (Britt *et al.* 2001, 2003). In fact, predatory pressure seems to also be a major concern for translocation projects elsewhere (Yeager and Silver 1999, Fischer and Lindenmayer 2000).

The management of these large predators seems to be necessary for the success of the *E. collaris* translocation project. For this, six *Cryptoprocta* were captured in 2004 in the conservation zone of Mandena. It is hard to understand how such a small forest (2.3 km^2) could have attracted such a high number of *C. ferox*. After extensive deliberations, some of the captured *C. ferox* were transported to Farafara and released in the humid forest of Tsitongambarika about 25 km north of Mandena. At least one of the animals returned to Mandena and was subsequently recaptured. The argument for the translocation of *C. ferox*, which prioritized conservation of *E. collaris* over the carnivores, was that the small forest of Mandena would be unable to maintain the population of *C. ferox*, and that this predator would move on after the lemur population had been depleted.

Table 4. Population dynamics of the translocated *Eulemur collaris* in the Mandena Forest.

Year	Birth rate [%]	Infant mortality [%]	Adult mortality [%]
2000	62.5	100	22
2001	100	0	25
2002	33	100	0
2003	100	50	0
2004	100	0	25

Despite the unanticipated problems caused by the immigration of *C. ferox*, the translocation of *E. collaris* was a success. The integration of the local village communities, local authorities, and QMM created a truly protected area for *E. collaris*, which had previously (before translocation) been hunted out of this forest. The project illustrates the potential uses of translocation projects for lemur conservation, as well as some of the pitfalls.

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