

First record of Fossa *Cryptoprocta ferox* in Mariarano forest, Madagascar

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<http://www.smallcarnivoreconservation.org>
ISSN 1019-5041

Abstract.

We surveyed the carnivore community in two patches of forest around Mariarano village in north-western Madagascar using camera traps. Cameras were set along trails in the forest and were active for a total of 517 trap nights. We recorded the presence of two indigenous carnivore species, Fossa *Cryptoprocta ferox* and Western Falanouc *Eupleres major*, and three introduced carnivore species; Small Indian Civet *Viverricula indica*, domestic dogs *Canis familiaris* and domestic cats *Felis catus*. This is the first record of *C. ferox* in the Mariarano forest area. We discuss the significance of this finding, as well as a potential extirpation of *E. major* in the Matsedroy forest patch.

Keywords: Camera trapping, deciduous forest, *Eupleres major*, Eupleridae

Premier signalement de Fossa *Cryptoprocta ferox* dans la forêt Mariarano, Madagascar

Résumé.

Nous avons sondé la communauté de carnivores dans deux parcelles de forêt autour du village de Mariarano dans le nord-ouest de Madagascar à l'aide de pièges photographiques. Des caméras ont été fixées le long des sentiers dans la forêt et ont été actives pour un total de 517 nuits de piégeage. Nous avons enregistré la présence de deux espèces indigènes de carnivores, le Fossa *Cryptoprocta ferox* et le Falanouc occidental *Eupleres major*, et trois espèces de carnivores introduits; la Petite civet indienne *Viverricula indica*, le chien domestique *Canis familiaris* et le chat domestique *Felis catus*. Ceci est le premier enregistrement de *C. ferox* dans la zone de la forêt Mariarano. Nous discutons de la signification de cette découverte, ainsi que d'une disparition potentielle de *E. major* dans la parcelle de forêt Matsedroy.

Mots clés: *Eupleres major*, Eupleridae, forêt de feuillus, piégeage-caméra

Introduction

Madagascar is the world's fourth-largest island and a global biodiversity hotspot with an abundance of endemic mammalian fauna (Myers *et al.* 2000, Mittermeier *et al.* 2005). However, many of these species are threatened by habitat loss and fragmentation (Irwin *et al.* 2010), as Madagascar's indigenous forest cover has been reduced by an estimated 43.85% from the 1950's to the year 2000 (Harper *et al.* 2007). Mammalian carnivores tend to be especially vulnerable to habitat loss and fragmentation due to their relatively large

spatial requirements (Woodroffe & Ginsberg 1998). In Madagascar, this situation is particularly acute, as relatively few studies have been done on the endemic carnivore species. This lack of data has resulted in carnivores being excluded from formal conservation plans for Madagascar (Kremen *et al.* 2008). Improved knowledge of the distribution, habitat preferences and disturbance tolerance of Madagascar's indigenous carnivores is thus of critical importance to their future conservation.

Our study presents results of a camera trapping survey conducted in remnant patches of western dry deciduous forest around Mariarano village located approximately 50 km north-west of Mahajanga in western Madagascar and builds on an existing dataset (see Evans *et al.* 2013). These forest patches are not formally protected, and are threatened by illegal timber extraction, charcoal production and clearing for agriculture (Washington *et al.* 2009, Long *et al.* 2012). Nevertheless, the forests around Mariarano contain a wide variety of lemur, reptile and bird species, including threatened species such as Coquerel's sifaka *Propithecus coquereli*, Leaf-tailed Geckos *Uroplatus* sp. and Madagascar Fish Eagle *Haliaeetus vociferoides*.

Since 2009, a long-term monitoring project of the area's biodiversity has been running collaboratively by Operation Wallacea, an international NGO, Development and Biodiversity Conservation Action for Madagascar, a community-based Malagasy conservation NGO, local community forest management groups, and the University of Antananarivo. Biodiversity surveys are done annually from June to August, during the local dry season. While most species are readily observed by the multidisciplinary teams who undertake the monitoring, indigenous carnivores are cryptic and seldom directly observed. Camera traps have been found to be the most effective means of gathering information on carnivore species at Mariarano (Evans *et al.* 2013). Our study aimed to gather data on carnivores in the Mariarano forest as part of the ongoing monitoring programme.

Materials and methods

Study areas

We sampled two discrete patches of forest in the vicinity of Mariarano village (see Figure 1). Mariarano forest (also known as Ankatsabe forest) borders Mariarano village on three sides (North, East and South), while the area to the west of Mariarano village has been cleared for cultivation. Sampling routes around Mariarano therefore sampled the western and central portions of Mariarano forest. In 2014, new sampling routes were demarcated to the west of Antafiemeva, a village on the eastern fringe of Mariarano forest. These new routes allowed for systematic sampling of the eastern side of Mariarano forest.

We also sampled in the area around Matsedroy Station, located in Matsedroy forest (also known as Analabe forest), which is located approximately 5 km to the west of Mariarano village. Matsedroy forest is separated from Ankatsabe by a broad strip of

cultivated land on either side of the Mariarano River. Matsedroy forest was noticeably more degraded than Mariarano forest, with signs of recent deforestation evident (Ibouroi *et al.* 2013).

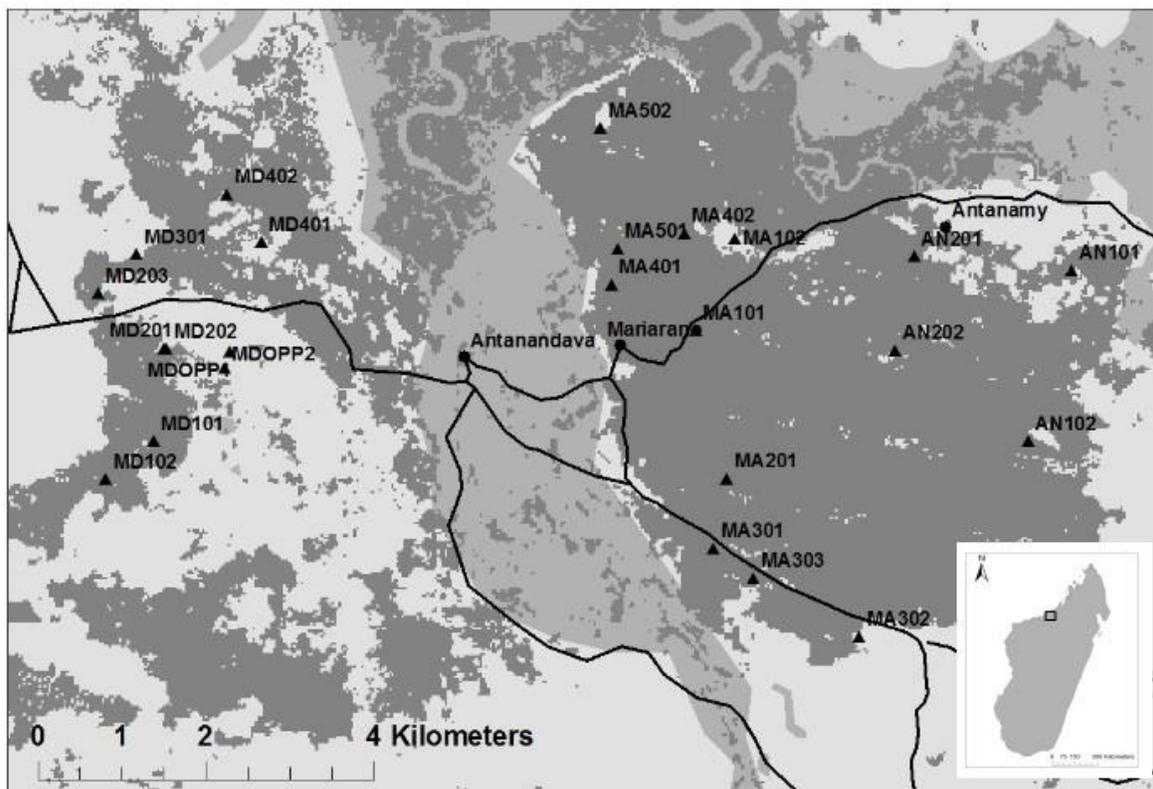


Figure 1. Map of the study area showing the position of the study area in Madagascar (inset), and locations of camera stations used in 2014. Forest patches are indicated by dark grey, intermediate-grey areas are wetland and riverine areas, while light grey represents open savannah areas with little tree cover.

Methods

We set 22 unbaited Bushnell TrophyCam HD camera traps along the existing network of seven sampling routes in the Mariarano forest, and four sampling routes in Matsedroy forest (Figure 1). Survey routes range from 1.7 to 3.6 km in length, and typically two cameras were placed on each survey route a minimum of 1 km apart. Camera sites were chosen on the basis of evidence of terrestrial mammal activity (*i.e.*, tracks and scats), as well as the advice of local guides. Two of the shorter routes (length ~1.6 km) only contained single camera sites, while additional cameras were positioned on two other, relatively long, sampling routes. A further two cameras were placed in opportunistic locations away from sampling routes. All cameras were set with their sensors approximately 30 cm high, and were programmed to record bursts of three photographs, with a 10-second gap in between capture events. We collected data from late June to late July 2014. The GPS coordinates of each camera site were recorded using a Garmin

GPSMAP 62s. Sampling effort was measured in trap nights; *i.e.*, a 24-hour period from midday to midday.

All animals recorded by the camera traps were identified to species level, and these data were entered into a spreadsheet together with the date, time and camera station at which the animal was recorded. Domestic animals were not included in our analyses, apart from domestic cats *Felis catus* and dogs *Canis familiaris* that did not appear to be accompanied by people. Dogs accompanied by people were assumed to be under human control, and therefore less likely to actively hunt wildlife, both due to social taboos, or faddy (Jones *et al.* 2008) and the dogs being fed rather than needing to hunt wildlife to survive. We assumed that repeated captures of the same species within one hour at a camera station were non-independent recaptures of the same individual, and therefore excluded these from subsequent analyses. Species accumulation curves were plotted for the area as a whole and for the individual forest patches using EstimateS version 9.2 (Colwell 2006). If the species accumulation curve did not reach an asymptote we used the Abundance Coverage Estimator (ACE) to estimate the total number of species likely to be present in the area (Chazdon *et al.* 1998).

Results

We obtained data from 20 camera traps that were active for a total of 517 trap nights, with each station active for a mean period of 25.85 (\pm SD) trap nights (\pm 6.39 days). Five camera traps were stolen during the course of the study, and no data were obtained from four of these. We recorded 78 independent captures of wildlife, of which 41 were of feral domestic cats and dogs. Cats were recorded 21 times at nine sites across the study area, while dogs were recorded 20 times at eight sites. Bushpigs *Potamochoerus larvatus* were the most frequently photographed wildlife species, recorded 25 times across seven sites. Five carnivore species were recorded in total; all five were present in Mariarano forest, but only three were recorded in Matsedroy forest. Carnivore capture records are summarised in Table 1. Species accumulation curves reached asymptote for Matsedroy forest (ACE = 3.00), but not for Mariarano forest (ACE = 5.41) or the area as a whole (ACE = 6.11), suggesting that overall camera trapping effort was insufficient to record all carnivore species in the area. Evans *et al.* (2013) reported local familiarity with Ring-tailed Mongoose *Galidia elegans*, and it is possible that this species is present in the area but was not recorded. Detailed records for wild carnivores are provided below:

Fossa *Cryptoprocta ferox*

Fossa are classified as Vulnerable on the IUCN Red List of Threatened Species (Hawkins & Dollar 2008). A single photograph of a *C. ferox* was recorded south of Mariarano village at 05h30 on 11 July 2014 on a portion of ox cart track that intersected the sampling route within an area of secondary forest (see Figure 2). This is the first confirmed record of *C.*

ferox in the Mariarano forest, although previous studies have suggested that they are likely to be present in the area (Long *et al.* 2012, Evans *et al.* 2013). This record does not constitute a range extension for *C. ferox*, which are thought to be widely distributed throughout low-altitude areas of Madagascar (Hawkins & Dollar 2008). Nevertheless, the nearest published record of *C. ferox* is 80 km away at Ankarafantsika National Park (Dollar *et al.* 2007, Garbutt 2007).

Table 1. Summary of carnivore camera trap data from the Mariarano forest, Madagascar, collected during the dry season in 2014.

Camera	South	East	Effort ¹	Species ²
MA101	15°28'36"	46°42'06"	21	<i>C. familiaris</i> (5)
MA102	15°28'06"	46°42'18"	0	Camera stolen
MA201	15°29'36"	46°42'18"	33	<i>F. catus</i> (1)
MA301	15°30'06"	46°42'42"	31	<i>E. major</i> (2), <i>C. familiaris</i> (5), <i>F. catus</i> (2)
MA302	15°30'3"	46°43'12"	31	<i>E. major</i> (2), <i>V. indica</i> (2), <i>C. familiaris</i> (1)
MA303	15°30'18"	46°42'30"	31	<i>C. ferox</i> (1), <i>V. indica</i> (3), <i>F. catus</i> (1), <i>C. familiaris</i> (5)
MA401	15°28'24"	46°41'30"	0	Camera stolen
MA402	15°29'00"	46°42'00"	0	Camera stolen
MA501	15°28'06"	46°41'36"	0	Camera stolen
MA502	15°27'24"	46°41'30"	30	
AN101	15°28'12"	46°44'36"	31	<i>F. catus</i> (2), <i>C. familiaris</i> (1)
AN102	15°29'24"	46°44'18"	31	<i>E. g. major</i> (2), <i>V. indica</i> (1), <i>F. catus</i> (4)
AN201	15°28'12"	46°43'30"	30	
AN202	15°28'48"	46°43'24"	30	
MD101	15°29'24"	46°38'30"	23	
MD102	15°29'36"	46°38'12"	23	<i>F. catus</i> (3), <i>C. familiaris</i> (1)
MD201	15°28'48"	46°38'36"	24	<i>F. catus</i> (3)
MD202	15°28'48"	46°38'36"	24	<i>F. catus</i> (3)
MD203	15°28'24"	46°38'06"	24	
MD301	15°28'12"	46°38'24"	24	
MD401	15°28'06"	46°39'12"	24	
MD402	15°27'48"	46°39'00"	24	<i>V. indica</i> (1), <i>F. catus</i> (4)
MDOPP1	15°28'48"	46°39'00"	24	<i>V. indica</i> (2), <i>F. catus</i> (1), <i>C. familiaris</i> (1)
MDOPP2	15°28'54"	46°39'00"	4	<i>V. indica</i> (2)

¹Effort refers to the number of trap nights for which the camera was active. The number of independent captures recorded for each species per camera station is shown in brackets after the species name.

²The numbers in parentheses correspond to the number of records.

Western Falanouc *Eupleres major*

Eupleres major is classified as Endangered in the current IUCN Red List (Dollar 2000). Individuals of this species were recorded six times at three sites. Two records, four days apart, were obtained from a site near Antafiemeva village, at 01h44 and 19h10, respectively. The remaining four records were obtained from two sites located south of Mariarano village, both in secondary forest along a track that ran parallel to the main road running south-east from Mariarano. Despite the relatively close proximity of these two sites, records were obtained on four different days, suggesting that these were independent capture events. Aside from one record at 19h10 (Figure 3), all *E. major* pictures were recorded within a period of less than one hour, from 01h44 to 02h39, suggesting a possible peak of activity during this time. Other studies have shown *E. goudotii* to be predominantly nocturnal (Gerber *et al.* 2012a), and our results suggest that this trend holds true for the *E.*

major population of Mariarano forest. Published records of *E. major* are scarce, but the species range is thought to extend from Antsiranana at the northern tip of Madagascar to close to Soalala on the west coast, at elevations ranging from 10 to 1,500 m (Goodman & Helgen 2010). *Eupleres major* has previously been recorded in the Mariarano Forest area (Evans *et al.* 2013), as well as approximately 70 km south-east of Mariarano at Marovoay and near Port Bergé, approximately 100 km to the east (Goodman & Helgen 2010).



Figure 2. Camera trap image of a Fossa *Cryptoprocta ferox* (left) recorded in the Mariarano forest, Madagascar, in July 2014. Although only the rear half of the animal was captured, the long tail is sufficient to identify the subject as *C. ferox*.

Small Indian Civet Viverricula indica

Viverricula indica is classified as Least Concern in the latest IUCN Red List (Choudhury *et al.* 2015), but it is not native to Madagascar (Garbutt 2007). This species was the most frequently photographed and widely distributed wild carnivore within the Mariarano Forest complex; it was recorded on 12 occasions at six sites spread across the study area. One individual was recorded by a camera set on a track in recovered secondary forest near Antafiemeva village at the easternmost extent of the study area. Six captures were recorded at two sites in secondary forest south of Mariarano village near the centre of the study area. One of these sites was on a major road frequently used by local people, both on foot and by ox cart, while the other was in a more isolated location near the forest edge to the south. Small Indian Civets were also recorded on the western side of the study area at three sites near Matsedroy research station. All the cameras that recorded *V. indica* in this area were situated in open areas or severely degraded secondary forest.



Figure 3. Camera trap image of a Western Falanouc *Eupleres major* recorded in the Mariarano forest, Madagascar, in July 2014

Discussion

This study provides further detail following the initial assessment of the wild carnivores of the Mahamavo forest (Evans *et al.* 2013), recording *C. ferox* in the area for the first time, as well as the Western Falanouc at a further three locations. The discovery of *C. ferox* in the area is interesting, given the isolation of the remnant forest at Mariarano from other patches of western dry deciduous forest (Moat & Smith 2007, Long *et al.* 2012). Fossa population density estimates range between 0.18 and 0.26 individuals per 100 km² in Kirindy Forest, another patch of Western dry deciduous forest (Hawkins & Racey 2005). Extrapolation of these estimates to the Mariarano forest would suggest a population of between 12 and 17 *C. ferox* individuals. However, these figures are likely to be overestimates, in that the Mariarano forest area also contains sizeable tracts of agricultural land, as well as a number of villages and smaller settlements, all of which are likely to adversely influence *C. ferox* abundance (Gerber *et al.* 2012b). Regardless, it can be safely assumed that the Mariarano forest *C. ferox* population falls well below the often-accepted threshold of 500 individuals required for a population to be viable in the long term (Thomas 1990). This suggests that the Mariarano forest *C. ferox* population is either a remnant population on the verge of extirpation, or that it forms part of a larger metapopulation that may include the nearest known population at Ankarafantsika National Park. However, Fossas' are thought to be relatively intolerant of disturbed habitats, preferring to remain close to forests (Gerber *et al.* 2012b, Kotschwar Logan *et al.* 2014). *C. ferox* presence has been suspected in Matsedroy forest since 2010, when local guides from Mariarano village claimed to have detected one

while leading a research group, and guides have consistently claimed that *C. ferox* is present in the Mariarano area. However, when findings of the 2014 survey were presented to the GIZ Boeny and Tanteraka (*i.e.*, local council), members stated that they were unaware of *C. ferox* presence in the area. This lends further credence to the notion that *C. ferox* densities are low in the area.

There was frequent overlap between carnivores at camera sites. The camera site where we recorded *C. ferox* also obtained records of *V. indica*, *C. familiaris* and *F. catus*. Similarly, introduced carnivores were also present at all three sites at which *E. major* were recorded. It is possible that both dogs and cats have a strong negative influence on non-domestic carnivores, through direct mortality, competition for food and space, and the spread of disease and parasites (Hawkins & Racey 2008, Barcala 2009, Gerber *et al.* 2012a). An apparent decline in *C. ferox* abundance at Ankarafantsika National Park was attributed to the growing population of stray dogs within the park (Barcala 2009). Although *C. ferox* are known to predate lemurs, ground-dwelling species are an important part of their diet, and all three introduced carnivore species are thus likely to compete with *C. ferox* for food (Hawkins & Racey 2008, Barcala 2009). Future monitoring of the local distribution of endemic and introduced carnivores is thus essential for conservation planning and management.

Evans *et al.* (2013) recorded six captures of *E. major* in 227 trap nights at a mean capture rate of 0.02 captures per night. Our study also recorded six captures, but with a far greater sampling effort of 517 trap nights (mean capture rate 0.01 records per night). This may indicate a decline in the abundance of *E. major*, especially as all the records obtained by Evans *et al.* (2013) were obtained in Matsedroy forest. We did not record any *E. major* in Matsedroy forest, despite our species accumulation curves suggesting that all species present in the area had been recorded. No records of *E. major* were obtained in 2013 either, albeit with a much lower sampling effort (*i.e.*, 80 trap nights). *Eupleres goudotii* is thought to be sensitive to habitat fragmentation (Gerber *et al.* 2012b), and it is possible that the continued degradation of Matsedroy forest has reached a threshold at which they are no longer able to persist in that forest patch. However, the low capture rate of *E. major* (six captures in 517 trap nights) suggests that this result be treated with caution. Future monitoring in Matsedroy forest, together with analytical tools such as occupancy modelling, will be used to develop more robust measures of the local distribution of this species.

While forest fragmentation has been identified as a major driver of extirpations of Madagascar's endemic carnivores, there is evidence to suggest that intact carnivore communities can persist in anthropogenically-modified forest areas (Gerber *et al.* 2012b). We did not encounter any evidence of hunting of endemic carnivores, and it is likely that these are protected by faddy (*i.e.*, local taboo) as has been recorded elsewhere in Madagascar (Jones *et al.* 2008). However, faddy does not confer universal protection; both

the perceived threat to humans and livestock and bushmeat hunting have led to the killing of endemic carnivores elsewhere in Madagascar (Jones *et al.* 2008, Barcala 2009, Golden 2009). Consequently, the ongoing involvement of local communities in biodiversity monitoring and conservation efforts in the Mariarano forest is thus key to preserving and maintaining the forest's carnivore biodiversity.

Acknowledgements

The authors would like to thank the Ministry of Forests and Environment for providing permits to work in the Mariarano forest and DREF Boeny. The surveys were implemented and funded by Operation Wallacea, Development and Biodiversity Conservation Action for Madagascar and the Département de Biologie Animale (DBA), University of Antananarivo. We are grateful to GIZ Boeny and VOI Tanteraka, and VOI Tanandava for accommodating our field camp at Mariarano village and for providing field guides and easy access to the forest at Mariarano and Matsedroy respectively. We would also like to thank the field guides at Mariarano, Matsedroy and Antafiemeva, who assisted our field work, as well as the Operation Wallacea students, volunteers, and support staff for their assistance. The authors would like to thank Dr. Frank Hawkins and one anonymous reviewer for comments that led to the improvement of this manuscript.

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