Two-spotted Palm Civet *Nandinia binotata* in Kibale Forest National Park, south-west Uganda (Photo: D. Mills)

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The views expressed in this publication are those of the authors and do not necessarily reflect those of IUCN, nor the IUCN SSC Small Carnivore Specialist Group. The aim of this publication is to offer the members of the IUCN SSC Small Carnivore Specialist Group, and those who are concerned with small carnivores in families of Ailuridae, Eupleridae, Herpestidae, Mephitidae, Mustelidae, Nandiniidae, Prionodontidae, Procyonidae and Viverridae, original papers, news items, abstracts, and titles of recent literature. Prospective authors (who need not be members of the specialist group) should submit material to the Editors-in-chief.

SCC is an Open Access journal, therefore does not charge authors, readers or their institutions for access to its contents.

CONTENTS

Editorial:
Small Carnivore Conservation in the Open Access, online era

We are in a period of time when access is paramount to the ability of science to better inform decision making. The Small Carnivore Specialist Group has met this challenge by developing a community forum through Facebook, and now moving the journal *Small Carnivore Conservation* completely online. As a journal composed entirely of volunteer editors, we also seek to develop a knowledge product that is streamlined in its efficiency, which can quickly review and publish manuscripts and which is not resource dependent. Therefore we are moving the journal entirely online, and in a new format and style to better accommodate the new venue.

Small Carnivore Conservation SCC, the official journal of the IUCN SSC Small Carnivore Specialist Group, is among the oldest journal of the Species Survival Commission and the IUCN, originally named *Mustelid and Viverrid Conservation*, and was first published in Belgium in 1989. As such, SCC defined a pathway and highlighted the importance of having such periodicals for most groups, an example that was rapidly adopted by other specialists groups such as Cats, Canids and Otters. Historically, *SCC* has been the leading journal for small carnivore (Ailuridae, Eupleridae, Herpestidae, Mephitidae, Mustelidae, Nandiniidae, Prionodontidae, Procyonidae, and Viverridae) research publication, providing a reliable and timely source of information for most of these families globally. Along its history, *SCC* has undergone a number of changes in order to advance and improve the journal from the time of its conception by Harry Van Rompaey in 1989 till date; the journal has changed both in scope and contents, adapting to the constant changes and challenges. The first change was the inception in 1992 of a new name, *Small Carnivore Conservation*, in order to include all ʻsmall carnivoreʼ families as it currently does. Further, in 2006, *SCC* expanded its scope by including more Editors and a new structure in order to fill the needs for maintaining the journal at its highest quality. The editorial team also made a huge effort to promote the publication of information from regions underrepresented in the journal otherwise: namely Africa and the New World. By including editors from these neglected regions, *SCC* is now proud to have a broader and frequent participation of authors from most of the globe and covering most of the species; a special issue on the Americas (volume 41) in 2009 (edited by J. Schipper, E. Eizirik, K. M. Helgen, J. F. González-Maya, M. Tsuchiya-Jerep and J. L. Belant) and a special issue on Africa (volume 48) in 2013 (edited by E. Do Linh San and M. J. Somers), are a good indicator of the global coverage of

our journal. So far, *SCC* (incl. Mustelid and Viverrid Conservation) is proud to have published 569 papers on almost all aspects of small carnivores' biology, ecology and conservation around the world.

In recent times, the world is more and better connected, with internet becoming a powerful and efficient way of sharing, distributing and disseminating scientific information. Once again in 2006, *SCC* in addition to the traditional publishing process of a printed periodical also came live online with a new website, where all the issues of SCC were archived and made available. Printing and distributing was an even larger challenge in terms of financial and logistic aspects of publication. Given the enormous opportunities and facilities that internet allows for rapid, high-quality publication of scientific research, and in order to cope with the fast-evolving world of publication, *SCC* is moving completely online (thus eliminating the print version) and adhering to the policies and global rules of the Open Access publishing, in order to stay updated and facilitate and accelerate dissemination of small carnivore research. From this volume (52 & 53), *SCC* becomes an online-only journal, and is taking the steps to include the Open Journal System, DOI coded among other modern technologies that facilitates the distribution and reach of our journal.

SCC has also gotten a facelift. In this issue we have updated our layout, taking advantage of the online-only approach, the second change in format in 26 years. Using the same template but with a fresh and renewed aspect, including full-colour figures and layout, and incorporates the requirements for the journal to be properly indexed by academic motors and internet search engines. We hope that these changes will have a greater effect on how our journal is reached and hopefully help to disseminate more efficiently small carnivore research to a wider audience. Additionally, we have expanded the editorial board, to include expertise in various aspects of the worlds' small carnivore ecology and conservation. The new editorial board is a combination of some of the most senior editors of the journal and some new and young field biologists, in order to be as inclusive and representative as possible. Our website is also renewed and updated with many new sets of information and repository of all the issues published since 1989, with full PDF access to all articles and issues.

We are living in a new era driven by the internet and globalization, therefore, we believe that these adjustments will help *SCC* to be up-to-date with the new challenges and enormous opportunities this new fast-paced world provides. We are more than grateful for the enormous and invaluable work of our previous editors, including Divya Mudappa, Will Duckworth and Jerrold Belant, which kept the journal at its best and even increased the quality and rigour of the manuscripts published, also promoting the participation of many new authors and the coverage of many species and regions. Thanks to their enormous and incredible work, *SCC* is now considered the best outlet for small carnivore research in the world; thanks!

Finally we would like to welcome the new Editorial Board and many new members of the IUCN SSC Small Carnivore Specialist Group, and we hope that this new era of *SCC*

will bring many good opportunities for the group but especially for the small carnivores around the world. We hope that you will enjoy the new face of *SCC* and we expect the journal to maintain its rigour and high-standard, with each issue becoming a sound and reliable source of information for the conservation of the worlds' small carnivores.

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Photo: Y. de Jong & T. Butynski

The diet of African Civet *Civettictis civetta* in two vegetation types of the Savannah biome in South Africa

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Abstract.

The diet of the African Civet *Civettictis civetta* was compared between two vegetation types in South Africa: Limpopo Sweet Bushveld (LSB) and Musina Mopane Bushveld (MMB), both located in the Savannah biome. Food items found in scat samples were similar in both vegetation types, but their frequency of occurrence differed. Wild fruits such as raisin bush *Grewia* spp. and invertebrate species like millipedes *Archispirostreptus gigas* formed the two major components of the Civet diet in both bushveld types. Fruit species were more abundant in the LSB scat samples with a 62.2% frequency of occurrence whereas invertebrate remains were more frequent (64.5%) in samples from the MMB. Remains of venomous scorpion species, mainly from the Buthidae family, were found in considerable quantities as well, the first time scorpions are reported to be part of the Civet diet. Our results confirm the omnivorous and opportunistic behaviour of the African Civets as their diet reflects the temporal availability of prey, fruits and seeds in their immediate habitat. Moreover, the large amount of seeds ingested by Civets suggests that they could act as an important seed disperser.

Keywords: African civet, scat analysis, diet, vegetation type, savannah biome.

Introduction

The African civet *Civettictis civetta* (Schreber 1776) is a medium-sized, fairly common carnivore that occurs in Sub-Saharan Africa (Ray *et al.* 2008). In South Africa, the density of two sub-populations is estimated at 10.1 ± 0.56 and 14.1 ± 4.15 civets/100 km² (Amiard 2014, Swanepoel *et al.* In prep.), suggesting a healthy population. However, despite the relative abundance across their range, little is known about the ecology of the species due to their elusive and secretive behaviour (Ray 1995).

To assess the role of carnivores such as civet in the ecosystem, it is essential to understand their diet and the relative contributions of different prey items (Ripple *et al.* 2014). Despite their elusiveness, investigate civets diet is relatively easy because they use communal latrines, called civetries, to defecate. These latrines are established in natural hollows in the ground near roads, normally less than 0.5 m^2 (Randall 1977, Bekele *et al.* 2008b). Civetries are characterized by large amounts of prey remains, such as seeds, insect remains and millipede rings (Bekele *et al.* 2008a). The few studies that quantified the remains in these civetries established that civets are omnivorous and their diet is dominated by fruits of various plants, insects and rodents (Ray 1995, Ray *et al.* 2005, Bekele *et al.* 2008a). Civets are also able to consume toxic prey such as millipedes and highly decayed carrion (Randall 1977, Ray *et al.* 2005).

Due to their function as a latrine, civetries also act as a source of information for other civets (Randall 1977). Civetries are used for 1) the exchange of information as civets can visit latrines without defecating themselves, 2) the familiarization with the home range as their position is remembered, and 3) the territorial demarcation as they are located at territorial borders (Randall 1977, Hutchings & White 2000). Besides their function as an information source for civets, civetries are also a source of information for researchers interested in the diet of this species.

The aim of this study was to quantify and compare the diet of the African civet in Limpopo Sweet Bushveld and Musina Mopane Bushveld (Acocks 1988), two vegetation types located in the Limpopo province of South Africa. In most habitats, plant communities determine the physical structure of the environment and therefore have a considerable influence on the distribution and interaction of species (Tews *et al.* 2004). The heterogeneous conditions and the environmental diversity in the two vegetation types, offer the possibility to study the response of civets to different environments through their diet.

Materials and methods

Study areas

Our study was conducted in the North of the Limpopo Province, in South Africa, where we selected four private reserves. The reserves fall within two different bioregions characterized by different vegetation types of the Savannah biome (Mucina *et al.* 2006) (Figure 1, Table 1).
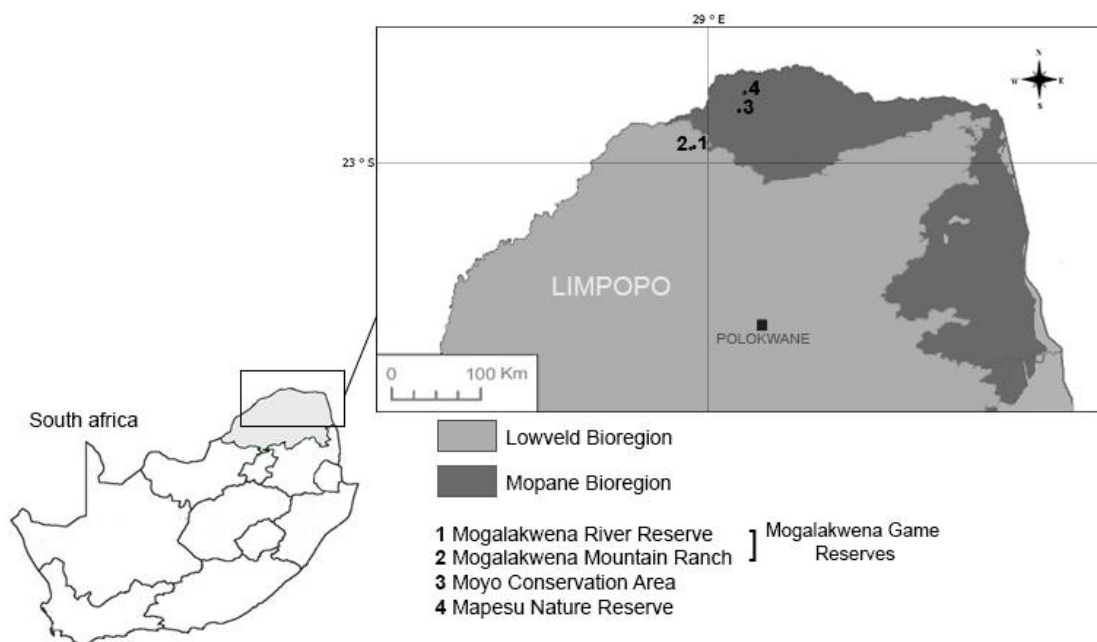
Figure 1. Localization of the study sites in the Limpopo province, South Africa.

Table 1. Complementary information about the reserves selected for the study.

Reserve		Area (hectares)	Coordinates*	Vegetation type
Mogalakwena Game Reserves	Mogalakwena River Reserve	1,400	22°43′32″ S 28°46′3″ E	Limpopo Sweet Bushveld
	Mogalakwena Mountain Ranch	2,000	22°43′30″ S 28°47′07″ E	
Moyo Conservation Area		1,000	22°28′14″ S 29°10′07″ E	Musina Mopane Bushveld
Mapesu Nature Reserve		6,000	22°14′14″ S 29°28′46″ E	

* Centre point of the reserve

On the one hand, Mogalakwena Reserves, with Mogalakwena River Reserve and Mogalakwena Mountain Ranch, are situated in the Limpopo Sweet Bushveld (LSB). The habitat of Mogalakwena River Reserve is described as a moderately closed to open shrubland where raisin bush *Grewia* spp., Umbrella Thorn *Acacia tortilis*, Purple-pod Cluster-leaf *Terminalia prunoides* and corkwoods *Commiphora* spp. are the dominant species. Whereas Mogalakwena Mountain Ranch is a predominantly closed habitat dominated by Mountain Syringa *Kirkia wilmsii*, corkwood species and Mountain Fig *Ficus glumosa*.

On the other hand, Moyo Conservation Area and Mapesu Nature Reserve are both located in the Musina Mopane Bushveld (MMB) vegetation type. The landscape is relatively flat with open woodland to moderately closed shrubveld dominated by Mopane *Colophospermum mopane*, raisin bush and Purple-pod Cluster-leaf.

Methods

Civetries were located during track surveys in the reserves from February to June 2014. Roads were walked five times per week covering different sections of the reserves between 07h00 and 10h00 and 15h00 and 17h00. When a new civetry was discovered, we recorded the GPS-coordinates. We visited each civetry every three weeks during the study period and collected randomly two to three scats (*i.e.*, one sample) per visit, which were kept in paper bags until analyses.

Scats were washed in running water through a brass sieve (*i.e.*, 0.5 mm diameter) until the water was clear. All undigested parts like seeds, hairs, bones, insect cuticles and millipede rings were separated and air-dried for 24 hours. These food items were then compared to reference collections and identified at the order level. Because scats could not be identified separately, the statistical unit is each unique civetry. The contribution of each food item to the diet was calculated as the frequency of occurrence in each civetry: FOi (%) = 100 x (number of occurrences of the food item i/total number of occurrences of all food items).

The standardized niche breadth index of Levins (Krebs 1999) was used to compare the degree of diet specialization per habitat type, by taking five food categories into account (*i.e.*, fruits, invertebrates, birds, mammals, and others). The index of Levins was calculated as: $BA = (B-1)/(n-1)$ with $B = 1/\Sigma p_j^2$ where pj is the fraction of food items that are of food category j and n the number of food categories present. The index ranges from 0 for very specialized diets to 1 for very generalist diets.

A Fisher's exact test was used to compare the homogeneity of the distribution of food items found in the scat samples from both vegetation types in R v.2.15.1 (R Core Team 2014).

Results

In total we found 22 civetries with 15,509 food items. All food items could be identified to the order level.

Limpopo Sweet Bushveld

During this study fourteen samples were collected, nine at the River Reserve and five at the Mountain Ranch. A total of 51 different prey species were found and were categorized in 13 groups of common food items (Table 2). Seeds of wild fruit species such raisin bush dominated the scat samples (*i.e.*, 66.1% at the River Reserve and 57.4% at the Mountain Ranch). A greater variety of fruit species was identified in the scat samples from the Mountain Ranch. Mountain Fig accounted for 15.3% of the diet and other fruits like Star Chestnut *Sterculia rogersii* and Marula *Sclerocarya birrea* contributed 5.3% to the civet diet. Invertebrates such as the African Giant Black Millipede *Archispirostreptus gigas* and Coleoptera species were the second most consumed food category. Invertebrate remains were found in similar proportions at both sites, although millipede remains were higher at the Mountain Ranch. Table 1 gives an overview of all food items found in scat and their frequency of occurrence.

Musina Mopane Bushveld

A total of eight samples were collected, three at Moyo Conservation Area and five at Mapesu Nature Reserve, and a total of 33 prey species were divided into 10 categories (Table 3). Invertebrate remains and seeds of wild fruits were the most common food items in the scat samples. Diet composition differed between the two sites. Seeds of Raisin bush were most frequent in scat samples from Moyo (55.7%), whereas invertebrate remains were the dominant prey item at Mapesu (82.6%). An overview of food items and their frequency of occurrence are given in Table 2.

Table 2. Food items found in the samples analysis from the Limpopo Sweet Bushveld vegetation type.

Food items	Parts eaten	Occurrences	FO (%)	FO (%) observed at the two sites	
				MRR	MMR
Grewia sp.	Fruits	5,582	52.76	66.0	36.7
Ficus glumosa	Fruits	731	6.91	-	15.3
Other fruits	Fruits	270	2.54	0.2	5.3
Archispirostreptus gigas	Whole	1,073	10.14	3.1	18.7
Coleoptera sp.	Whole	1,984	18.75	18.8	18.7
Orthoptera sp.	Whole	182	1.72	2.2	1.1
Diptera sp.	Whole	6	0.06	0.1	0.0
Scorpiones sp.	Whole	64	0.60	0.9	0.3
Francolinus sp.	-	136	1.29	0.7	2.0
Rodentia sp.	Whole	274	2.59	4.4	0.4
Other mammals	-	5	0.05	<0.05	0.1
Grass	-	269	2.54	3.6	1.3
Plastic / Foil *	-	3	0.03	0.1	-
Total	**-**	**10,575**	**100**	**100**	**100**

With: MRR = Mogalakwena River Reserve and MMR = Mogalakwena Mountain Ranch.
*Probably eaten with human food waste found around lodges.

Table 3. Food items found in the samples analysis from the Musina Mopane Bushveld vegetation type

Food items	Parts eaten	Occurrences	FO (%)	FO (%) observed at the two sites	
				MCA	MNR
Grewia sp.	Fruits	1,288	26.1	55.7	1.4
Other fruits	Fruits	19	0.4	0.6	0.2
Archispirostreptus gigas	Whole	2,052	41.6	21.0	58.8
Coleoptera sp.	Whole	558	11.3	21.3	3.0
Orthoptera sp.	Whole	549	11.1	0.4	20.0
Scorpiones sp.	Whole	22	0.4	-	0.8
Francolinus sp.	-	328	6.6	<0.05	12.2
Rodentia sp.	Whole	45	0.9	0.8	1.0
Grass	-	71	1.4	0.1	2.5
Plastic / Foil *	-	2	<0.05	-	0.1
Total	**-**	**4,934**	**100**	**100**	**100**

With: MCA= Moyo Conservation area and MNR= Mapesu Nature Reserve.
*Probably eaten with human food waste found around lodges.

Comparison between the two vegetation types

Seeds of wild fruits appear to be more frequent in the LSB scat samples (62.2%), whereas invertebrate remains and in particular that of millipedes dominated the samples from the MMB vegetation type (64.5%). A higher proportion of bones, hairs and/or feathers were found in the scat samples from MMB (*i.e.*, 7.5% compared to 4.0% for LSB). In more detail, we identified a higher proportion of rodent remains in the scat from the LSB (*i.e.*, 2.6% compared to 0.9% in the MMB), but remains of bird species were more frequently encountered in scats from the MMB (*i.e.*, 6.6% compared to 1.3% in the LSB). The proportion of food items observed in scat samples were significantly different between the two vegetation types (Fisher's exact test: $P < 0.001$).

According to the Levin's index, civets from the LSB seem to have a similar standardized trophic niche (BA-LSB = 0.264) as civets from the MMB vegetation types (BA-MMB = 0.260).

Discussion

In this study we compared the diet of the African Civet between two vegetation types. In both bushveld types, civets had an omnivorous diet as described before (Randall 1977, Smithers 1986, Bekele *et al.* 2008a), with wild fruits and invertebrates dominating the diet. More than 70% of the civet diet consisted of non-vertebrate food items, which would make the civets in our study hypo-carnivores rather than meso-carnivores (van Valkenburgh 2007), at least during our study period. Recent findings in Ethiopia confirm this suggestion (Bekele *et al.* 2008a, Mull & Balakrishnan 2014). Thirteen categories of common food items in the Limpopo Sweet Bushveld and 10 categories in the Musina Mopane Bushveld were defined. However, in the LSB wild fruits such as raisin bush dominated the diet, whereas in the MMB invertebrates (*i.e.*, mainly African Giant Black Millipede) were the most abundant prey species. Civets from the LSB consumed a wider variety of food species than civets from the MMB.

On the Mogalakwena Reserves, fruit-bearing trees are more abundant than at the Moyo and Mapesu reserves (Mucina *et al.* 2006, Fauré 2010, Benichou 2013), which most likely explains why wild fruits are the dominant species in the civet diet in the LSB. Also, when seeds were found in scats, one fruit species generally dominated the composition of the scat. This observation would suggest that particular fruit species were ingested in great quantity at the same time, likely representing the seasonal abundance of particular fruits. Civets thus have the capacity to adapt their feeding behavior and take advantage of temporarily available resources in their environment.

Due to their frugivorous nature, civets could act as an important seed disperser through endo-zoochory (Randall 1977, Pendje 1994). Some important criteria are met by civets to act as seed dispersers, like covering large surface areas and having long digestion times characteristic of carnivores (Zhou *et al.* 2008), and selecting microhabitats for defecation through civetries. Indeed, it was not uncommon to observe seeds germinating in civetries during scat collection. Seed dispersal by Civets in shrublands could be an interesting topic to investigate in future studies because of its ecological impact. For example, raisin bush species are known to be involved in the shrub encroachment process in the savanna biome (Trollope 1982, Roques *et al.* 2001, Tews *et al.* 2004) and civets could play a significant role in this.

Civets are known to be able to eat millipedes and highly decayed carrion (Randall 1977, Ray 1995, Ray *et al.* 2005). African giant black millipedes secrete an irritating fluid that makes them unpalatable to predators (Eisner *et al.* 1978) but nevertheless they were an

important food resource for civets in many studies (Randall 1977, Bekele *et al.* 2008a, Mullu & Balakrishnan 2014), including our study. Many Viverrid species are able to eat noxious prey and resist their toxins (Randall 1977). But surprisingly scorpion species, and especially from the Buthidae family, were also found in significant quantities in civet scats. Several of the consumed scorpion species, such as *Parabuthus transvaalicus* and *P. mossambicensis*, are highly toxic (Leeming 2003), but nevertheless present in the scats from the Mogalakwena Game Reserves. The consumption of poisonous species has been reported in cooperative animals like Banded Mongooses *Mungos mungo* and Meerkats *Suricata suricatta* (Barett *et al.* 2012), but not for a solitary species like the African Civet. Malay Civets *Viverra tangalunga*, in the rain forest of Borneo, are known to eat scorpions as well (Colon & Sugau 2012) but these species are relatively harmless (Garbutt & Prudente 2006). To our best knowledge this is the first time it was shown that civets can feed on toxic scorpions. The ability to eat such prey allows the African civet to take advantage of a dietary resource not consumed by other same sized carnivores.

In the MMB, civet scats contained more vertebrate remains like hairs, feathers and bones than in the LSB. Overall, civets showed a higher consumption of protein-rich food items in the MMB compared to LSB, including invertebrates, birds such as francolins *Francolinus* spp., and rodents like Pouched Mice *Saccostomus campestris*. No hair or bone remains were found in scats from the LSB, but camera traps set at the same time as our study, showed that civets did feed on large herbivore carrion, in this case Giraffe *Giraffa camelopardalis*. Probably due to the large availability of wild fruits during our study, civets had easy access to food and did not have to supplement their diet with extra protein. It would be interesting to investigate the proportion of vertebrates in the diet outside the fruiting season, as we expect this proportion to increase (Bekele *et al.* 2008a).

Undigested grasses were often encountered in the scat samples. Grass ingestion is considered to be a form of self-medication facilitating digestion (Bekele *et al.* 2008a) or helping with the elimination of parasites. Plant ingestion is reported for various carnivore species like the GrayWolf *Canis lupus*, the Black-backed Jackal *Canis mesomelas* and the Small Indian Civet *Viverricula indica* for example (Huffman *et al.* 2012, Su *et al.* 2013).

Anthropogenic food items were identified in the samples as well. Mainly pieces of plastic and foil were found, indicating that Civets fed on human food waste, which has been reported before (Bekele *et al.* 2008a, Barett *et al.* 2012). Civets are suspected to be involved in crop raiding in many areas of Africa and are willing to travel long distances for these (Bekele *et al.* 2008a). Even though there are croplands within 5 km from Mogalakwena Game Reserve, no seeds from fruit crops were found during the scat analysis, possibly again indicating that wild fruits were readily available during our study. More investigations on crop raiding patterns are required to confirm these suspicions.

The wide variety of different food items found in the diet of African Civet suggests that this species is highly opportunistic, which might explain its relative abundance throughout its range. By taking advantage of food that is most abundant at different times of the year, African Civets are able to survive in different habitats under variable conditions.

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ORIGINAL ARTICLE

A review of evidence for the presence of Two-spotted Palm Civet *Nandinia binotata* and four other small carnivores on Bioko, Equatorial Guinea

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Abstract.

Several standard reference works report the presence of Two-spotted Palm Civet *Nandinia binotata* on Bioko Island, Equatorial Guinea. However, numerous field and bushmeat market surveys over the past 30 years have failed to record this species, hence raising concerns that it is either extremely rare or extirpated. This article reviews evidence for presence of *N. binotata* on Bioko and simultaneously remarks on the occurrence of four other small carnivores on this island. There is strong evidence that *N. binotat*a, King Genet *Genetta poensis*, Large-spotted Genet *Genetta maculata* (*sensu lato*), and an otter (initially described as *Lutra poensis*) never occurred on Bioko. Central African Oyan *Poiana richardsonii* is the only mammalian carnivore (small or large) unequivocally recorded for Bioko. Anecdotal observations suggest that a second, unidentified, species of small carnivore may occur. Future field workers on Bioko are encouraged to obtain photographs of small carnivores, and to collect, preserve, and make known, any dead small carnivores they encounter.

Keywords: Bioko Island, bushmeat, carnivore, *Genetta*, *Nandinia*

Una revisión de la evidencia de la presencia de la Nandinia *Nandinia binotata* y otros pequeños carnívoros en Bioko, Guinea Ecuatorial

Resumen.

Varios trabajos de referencia estándar reportan presencia de *Nandinia Nandinia binotata* en la Isla de Bioko, Guinea Ecuatorial. Sin embargo, numerosos estudios de campo y de mercados de carne de animales silvestres en los últimos 30 años no han logrado registrar esta especie, por lo tanto, aumentando las preocupaciones de que o bien es muy raro o fue extirpado. Este artículo revisa la evidencia de la presencia de *N. binotata* en Bioko y, simultáneamente, comenta sobre la aparición de otros cuatro pequeños carnívoros en esta isla. Hay una fuerte evidencia de que *N. binotata*, Gineta Real *Genetta poensis*, Gineta de Manchas Grandes *Genetta maculata* (*sensu lato*), y la nutria (descrito inicialmente como *Lutra poensis*) nunca ocurrió en Bioko. El Oyán *Poiana richardsonii* es el único carnívoro mamífero (pequeño o grande) inequívocamente registrado en Bioko. Observaciones anecdóticas sugieren que una segunda especie, no identificada, de pequeño carnívoro pueda ocurrir. Se anima a los futuros trabajadores de campo en Bioko que obtengan fotografías de los pequeños carnívoros, y que recojan, preserven y divulguen sus resultados así como los pequeños carnívoros muertos que encuentren.

Palabras clave: Isla de Bioko, carne de animales silvestres, carnívoro, *Genetta*, *Nandinia*

Introduction

Bioko (formerly Fernando Pó or Poo, after its Portuguese discoverer) is a 2,017-km² continental-shelf island in the Gulf of Guinea. The island lies 37 km off the coast of Cameroon having been separated from the mainland 10,000–12,000 years ago by rising sea levels (Eisentraut 1965, Jones 1994, Butynski *et al.* 1997, Oates *et al.* 2004, Cronin *et al.*

2014). Bioko shares with the African mainland most of its mammal fauna, although it harbours several endemic mammal species, including Eisentraut's Mouse Shrew *Myosorex eisentrauti* and Pennant's Red Colobus *Procolobus pennantii*. Five small carnivore species, all originally described from Bioko, are documented to occur (see Harrington *et al.* 2002 for a review).

The Two-spotted Palm Civet *Nandinia binotata* is the only species in the family Nandiniidae. In the past, the species was considered a member of the Asiatic subfamily Paradoxurinae – and, indeed, is sometimes called 'African Palm Civet' – or of the subfamily Nandiniinae in the family Viverridae. However, morphological and molecular studies conclusively demonstrated that the species is basal to all other feliforms, and belongs in its own family (see Gaubert 2013a and references therein).

An African endemic, Two-spotted Palm Civet is found in lowland, mid-altitude and montane forests from Gambia in West Africa to south-western South Sudan, Uganda and central Kenya in East Africa, and south through Central Africa to northern Angola and north-western Zambia. In the east, it occurs in a narrow belt southwards to around the Chimanimani Mountains between Zimbabwe and Mozambique (van Rompaey & Ray 2013). Besides the African mainland, the species occurs on Zanzibar, Tanzania (Perkin 2004).

Despite reports of Two-spotted Palm Civet on Bioko, Equatorial Guinea, in standard reference works (*e.g.,* Coetzee 1977, Haltenorth & Diller 1980, Kingdon 1997, Gaubert 2009, van Rompaey & Ray 2013), numerous field and bush-meat market surveys over the past 30 years have failed to record the species, hence raising concerns that it is either extremely rare or extirpated.

Here, evidence for the presence of Two-spotted Palm Civet on Bioko is reviewed and an alternative hypothesis proposed, namely that the species never occurred on Bioko. Simultaneously, evidence for the possible presence of the four other documented carnivores on Bioko is discussed.

Does Two-spotted Palm Civet occur on Bioko?

Despite inclusion in recent major reference works, most early authors focusing on Bioko do not list Two-spotted Palm Civet as part of the island's fauna. Thomas (1904), for example, provided a list of the known indigenous mammal fauna on Bioko, based primarily on Bocage (1903), to the exclusion of Two-spotted Palm Civet. Cabrera (1908) listed it, noting only that Thomas (1904) had excluded it while other authors presumed its existence. Later, Cabrera (1929) remarked only that confirmation of the species from Bioko was required. Krumbiegel (1942), who analysed materials collected on Bioko by Hermann Eidmann, makes no reference to any carnivores in Eidmann's collection and only lists "*Nandinia binotata*" in passing as part of the fauna.

Eisentraut (1973), in his monograph on the mammals of Bioko, considered Two-spotted Palm Civet to be very rare and never recorded a specimen. Indeed, he was ready to remove the species from his inventory except that "Padre Basilio" told him of a young female captured in January 1956 near Moca in the Southern Highlands. Eisentraut conducted faunal surveys in Moca Valley, and the eponymous Father Basilio's Striped Mouse *Hybomys basilii* is described from specimens collected by Eisentraut in this valley. Padre Aurelio Basilio was a priest who lived on Bioko (then still Fernando Pó) from the mid-1940s until about 1972. Basilio's (1952) treatise on the wildlife of Equatorial Guinea notes only that the species occurs but gives no further comment. Oddly, Basilio's (1962) second edition of his work makes no mention of his own 1956 record of Two-spotted Palm Civet from Moca.

Field surveys on Bioko have increased considerably since 1986 (*e.g.*, Butynski & Koster 1994, Cronin *et al.* 2014). Several hundred researchers and their students have undertaken tens of thousands of hours of field research on Bioko over the past 30 years; thousands of kilometres of diurnal and nocturnal surveys along transects have been walked, and thousands of hours of fixed-points have been conducted. In addition, researchers and students have logged several thousand 'camp nights' in the field. These surveys and camps have occurred at numerous sites on Bioko, including many of the most remote sites. All of these activities present good opportunities for encounters with small carnivores. Yet, despite the extensive field research that has been undertaken on Bioko since 1986, Two-spotted Palm Civet has not been encountered.

Surveys of bush-meat markets have also increased in the past few decades. On the mainland, Two-spotted Palm Civet is commonly recorded in bush-meat markets; indeed, the species was the most common carnivore recorded (*i.e.*, 60% of 121 carcasses) in two markets in Río Muni, on Equatorial Guinea's mainland (Juste *et al.* 1995). On Bioko, bush-meat market surveys conducted during 1997–2000 recorded nearly 38,000 animals, but no Two-spotted Palm Civets (Harrington *et al.* 2002). The species also was not recorded on Bioko in bush-meat surveys by other researchers through much of the 1990s and early 2000s (*e.g.*, Fa *et al.* 1995, 2000, 2002, Albrechtsen *et al.* 2007), despite continuing to be reported in markets in Río Muni (*e.g.*, Kümpel 2006).

The Two-spotted Palm Civet began sporadically occurring in the Malabo market in 2004, roughly corresponding with the start of a period of rapid market growth and demand and increased numbers of carcasses imported from the mainland (Cronin *et al.* 2015). During the period 1997–2010, 1,241 Two-spotted Palm Civet carcasses were recorded in the Malabo market, relative to 588 Central African Oyan *Poiana richardsonii* (which have appeared in low numbers consistently since 1997). Based on interviews with hunters and personal observations, Cronin *et al.* (2015) reported that none of the Two-spotted Palm Civet carcasses were from Bioko. Available evidence suggests that the costs and risks associated with carcass transport to Bioko are largely negated by higher profit potential in

the Malabo market relative to markets in Nigeria, Cameroon or Río Muni (Morra *et al.* 2009, Cronin *et al.* 2015).

The questionable presence of Two-spotted Palm Civet on Bioko was discussed decades earlier by Rosevear (1974) whose argument hinged on the origin of the only two known specimens of the species, both supposedly from Bioko. The first, the type, *Paradoxurus hamiltoni* (see additional note after references: #1), described by Gray (1832) from a living specimen in the Surrey Zoological Gardens, had been in the possession of Edward Cross for two years. It had its type locality given, wrongly, as India, and was subsequently amended by Gray (1843) to "Fernando Poo", presumably based on information provided by Cross. Rosevear regarded this revised provenance with great suspicion, and considered it likely that knowledge of the origin of the type had merely crystallized itself into Fernando Pó, given its importance at the time as a port of call for merchant ships. Indeed, during Fernando Pó's period of British administration, a steady stream of skins and skeletons from Africa's wildlife passed through the capital of Fernando Póo, Port Clarence (now Malabo), bound for presentation at meetings of the Zoological Society of London (Hearn & Morra 2001). The second specimen remarked on by Rosevear is a British Museum skin (No. 55.12.24.413) that apparently formed part of a parcel of more than 1,000 specimens purchased in 1855 by the British Museum from the Zoological Society of London. The provenance of this skin is also unclear.

What evidence for other documented small carnivores on Bioko?

Besides Two-spotted Palm Civet, four other small carnivore species are documented as occurring on Bioko. Central African Oyan was originally named from a specimen (deposited in the British Museum as No. 41.10.18.1) collected by T.R.H. Thomson from Bioko. Thomson (1842) notes in his description that he "…received it from the Bobys [Bubi's] or natives of the island, and they had skinned it through the mouth without making any other incision in the skin". This bears remarking on because, unlike any of the other carnivores described from Bioko, the Central African Oyan appears to be the only one whose provenance is unequivocally demonstrated in its original description. This species has been frequently encountered on the island, both in the wild and in bush-meat markets, by many researchers (including TMB, DC, and GH).

Prior to the description of the Central African Oyan, Waterhouse (1838) described two species of carnivores from Bioko, an otter *Lutra poensis* (see additional note #2) and the King Genet *Genetta poensis*, both of which today remain known for Bioko only from their type specimens. According to the original description, the specimens "…had been given to the [Zoological] Society's Museum by George Knapp, Esq., who in turn had received them from the island of Fernando Poo". As with Two-spotted Palm Civet, the precise origin of these two specimens has been in some doubt and several authors have questioned whether they may, in fact, have come from the mainland (*e.g.*, Pousargues 1896,

Pocock 1908, Cabrera 1929, Basilio 1952, Eisentraut 1973, Rosevear 1974). In his original description, Waterhouse (1838) also described several additional species from Bioko from specimens from the same collection, including *Colobus* (*Procolobus*) *pennantii*, Black Colobus *Colobus satanas*, Red-eared Monkey *Cercopithecus erythrotis*, and Ogilby's Duiker *Antilope* (*Cephalophus*) *ogilbyi*. All species are still found on Bioko, albeit all in decline (Hearn & Morra 2001, Hearn *et al.* 2006). Waterhouse was Curator of the Zoological Society of London's museum from 1836 to 1843. He selected the specimens upon which his descriptions were based from a larger number of skins. Some of these skins must have originated from Bioko but, as elaborated upon above for Two-spotted Palm Civet, it is possible that many of these specimens originated from the mainland (indeed all except Pennant's Red Colobus also have mainland distributions).

Harrington *et al.* (2002), commenting on the presence of *L. poensis*, make reference to Mary Kingsley's (1897) "Travels in West Africa" in which she notes "Elephants, though plentiful on the adjacent mainland, are quite absent from Fernando Po, as are also hippos and the great anthropoid apes; but of the little gazelles [presumably a reference to duikers], small monkeys, porcupines, and squirrels he has a large supply, and in the rivers a very pretty otter (*Lutra poensis*) with yellow brown fur often quite golden underneath". This description closely matches that given by Waterhouse. Harrington *et al.* (2002) surmised that the species may have been hunted to extinction for its fur in the 1800s before its presence was properly documented. However, we suspect that Kingsley did not observe the animal herself and was merely borrowing from published knowledge (Waterhouse's description and the Latin name) in stating that *L. poensis* existed on Bioko. Indeed, if Kingsley had seen this species, and considered it common enough to mention, it would suggest a rapid extirpation given its apparent absence by the time Eidmann, Basilio, Eisentraut and others visited the island. In any event, there is little doubt that no otter survives on Bioko today.

King Genet continues to be treated as part of Bioko's fauna (*e.g.*, Jennings & Veron 2009, Gaubert 2013b) despite it being based on a single specimen of disputed provenance. Interestingly, the type specimens of the otter and the King Genet were catalogued in the British Museum as No. 55.12.24.414 and No. 55.12.24.412, respectively. As such, they likely formed part of the aforementioned shipment that was purchased in 1855 by the British Museum from the Zoological Society of London.

Besides King Genet, a second genet species has been described from Bioko: Cabrera (1921) described *Genetta insularis* based on a specimen apparently taken in Rebola (north Bioko) and held in the National Museum of Natural History (No. 20-VII-22-6), Madrid, Spain. This form has invariably been treated as a synonym of other 'large-spotted' forms, most recently with Large-spotted Genet *Genetta maculata* (*sensu lato*; Gaubert 2003). Hence, Bioko is invariably included in the range of this species. As with King Genet, this form remains known only from the type specimen, and Cabrera himself

suggested that it was not possible to confirm its origin. No native genet has ever been documented for Bioko, despite numerous diurnal and nocturnal field surveys over almost the entire island during the past 30 years.

Conclusions

Assuming Two-spotted Palm Civet, a genet, or an otter did historically occur on Bioko, what could have caused their extirpation? There is no biogeographic reason why they should not occur given, for example, presence of the Central African Oyan. Nevertheless, there are a large number of mammals with distributions on the continent in the Gulf of Guinea that do not occur on Bioko, including any species of herpestid (Herpestidae), lorisoid (Lorisidae), baboon-mangabey (*Lophocebus* spp.), drill-mangabey (*Cercocebus* spp.), pig (Suiformes), or antelopes in several tribes (see Bioko Biodiversity Protection Program 2007 for a comparison of mammals inhabiting Bioko with those inhabiting Mt Cameroon during the latter half of the 20th Century; see Additional note #3).

The only species with a mainland distribution conclusively documented to occur on Bioko and that is no longer present is the African Forest Buffalo *Syncerus caffer nanus*. This species was likely extensively hunted, its elimination from Bioko probably facilitated by introduction of firearms by Europeans in the 1800s and an increasing demand for meat as the island's population grew alongside increased cacao production (Butynski *et al.* 1997). TMB suspects that the buffalo was introduced to Bioko by Europeans. If so, there appears to be no example of the extirpation of a native species from Bioko. While a small carnivore species may have been subjected to localized, targeted hunting, there is no obvious explanation why it should be extirpated, while larger – arguably more preferred (Fa *et al.* 2002) and more targeted (Cronin *et al.* 2015) – species, such as duikers and primates, were not. It should be noted that:

1. Much of the human population on Bioko is concentrated in Malabo and at a few villages along the coast. Even today there are large areas on Bioko, some of them very difficult to access (including deep, steep, river valleys) and/or remote, where hunting of smaller-bodied mammals appears to be at low levels. It seems inconceivable that any small carnivore could have been extirpated from Bioko as a result of hunting by humans.

2. The Two-spotted Palm Civet and some other *Genetta* spp. do well in and near human-altered habitats and landscapes, such as scattered croplands and secondary forest (Gaubert *et al.* 2015a, b). They are also, typically, readily observed, particularly at night as they give much reflective eye-shine and are not particularly shy. In the case of Two-spotted Palm Civet, the loud call is also very distinctive and can be heard up to 1 km by the human ear (this call can be downloaded at www.wildsolutions.nl).

3. In the case of otter, there remain several near-pristine rivers in remote areas on Bioko, particularly over the southern one-third of the island. There is little, or no, human activity along these rivers, all of which are very difficult of access over most of their length. It is hard to imagine that a species that is as difficult to hunt as the otter, could have been extirpated from these rivers.

In summary, although it cannot be conclusively ruled out that Two-spotted Palm Civet, two species of genet or an otter once occurred on Bioko, the evidence available to support their historical presence is scant and cannot be validated. In the absence of any records of these species in during numerous field or bush-meat surveys (more than 195,000 carcasses from the Malabo market have been observed since 1997) over the past 30 years, and their likely persistence in the face of hunting pressure and habitat change, it seems appropriate to reject all four species as being part of Bioko's fauna.

Despite the evidence presented above, one cannot discount the possibility that, besides Central African Oyan, another small carnivore species occurs on Bioko. Harrington *et al.* (2002) reported what appeared to be an unidentified arboreal carnivore sighted on two occasions in the Gran Caldera (remote south-western Bioko) in January 2000. GH recalls a third fleeting encounter in January 2006 with a mammal more heavier-set than a Central African Oyan, moving along a stream-bed at the northern end of the Gran Caldera. If another small carnivore does occur on Bioko, then it can only be said that it is very rare and probably localized in occurrence.

It is hoped that this note will encourage future field workers to be vigilant for small carnivores on Bioko. They are urged to obtain photographs of small carnivores, and to collect, preserve, and make known, any dead small carnivores they encounter.

Acknowledgements

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Additional Notes

#1 - Most authors (*e.g.*, Allen 1939, Wozencraft 2005) attribute the original description of the species to Gray (1830) based on a specimen in the Netherlands Museum in Leiden in Spicilegia Zoologica (p. 9) under the heading *Viverra binotata*, and to which the type locality "Africa, Ashantee" (present day Ghana) is given. However, Rosevear (1974) notes that the type was missing and could not be traced.

#2 - Precise taxonomic status of the otter Waterhouse described is unclear. Rosevear (1974) included it in African (Cape) Clawless Otter *Aonyx capensis*, noting that it might not even be *Aonyx* at all, but a *Lutra*. He further notes that the skin is likely of a young animal, without feet, and that characters of colour are without diagnostic value. Indeed, Wozencraft (2005) treated it as a subspecies of Spotted-necked Otter *Lutra* (*Hydrictis*) *maculicollis*.

#3 - Although not a small carnivore, it is worth noting that some faunal treatises list Giant Pangolin *Smutsia gigantea* from Bioko (*e.g.*, Kingdon *et al.* 2013). However, the species is not mentioned by Thomas (1904), Cabrera (1908, 1929), Krumbiegel (1942), Basilio (1952), or Eisentraut (1973), all of whom consistently only mention White-bellied Pangolin *Phataginus tricuspis*. Giant Pangolin also has not been recorded by any recent field workers on the island. The only explanation for supposed occurrence of Giant Pangolin on Bioko is related to records of carcasses in bushmeat markets, transported from the mainland to Malabo.

ORIGINAL ARTICLE

Distribution, habitat ecology and conservation status of the Two-spotted Palm Civet *Nandinia binotata* (Carnivora, Nandiniidae) in south-eastern Nigeria

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Abstract.

The Two-spotted Palm Civet *Nandinia binotata* is widespread across tropical Africa but its ecology is not well known, with virtually no data existing for Nigeria. This study provides data on the distribution, habitat ecology and conservation status of this species in south-eastern Nigeria. Based on a combination of bushmeat market and field surveys, we found that *Nandinia binotata* appeared to be more common in River Niger Delta forests than in the deforested areas of Abia and Akwa–Ibom States, and probably also Cross River State. Higher-than-expected sample sizes were obtained in second-growth forests, while fewer Civets than expected were collected or observed in mature forests and plantations. An apparent decline of the population was observed at two forest village areas in Cross River State over the last 20 years.

Keywords: ecology, *Nandinia binotata*, natural history, threats, bushmeat, Nigeria

Distribution, écologie de l'habitat et statut de conservation de la Nandine *Nandinia binotata* (Carnivora, Nandiniidae) dans le sud-est du Nigéria

Résumé.

La Nandine (ou Civette palmiste africaine) *Nandinia binotata* est répandue en Afrique tropicale, mais son écologie n'est pas bien connue et il n'y a pratiquement aucune donnée disponible pour le Nigéria. Cette étude fournit des données sur la distribution, l'écologie de l'habitat et le statut de conservation de cette espèce dans le sud-est du Nigéria. Basé sur une combinaison de données provenant de marchés de viande de brousse et d'enquêtes de terrain, nous avons constaté que *Nandinia binotata* semble être plus commune dans les forêts de la rivière du Delta du Niger que dans les zones déboisées d'Abia et d'Akwa–Ibom, et probablement aussi de l'Etat de Cross River. Des tailles d'échantillons plus élevées que prévu ont été obtenues dans les forêts secondaires, tandis que moins de Nandines qu'attendu ont été capturées ou observées dans les forêts matures et les plantations. Une baisse apparente de la population a été observée dans deux zones villageoises forestières dans l'Etat de Cross River au cours des 20 dernières années.

Mots-clés: écologie, *Nandinia binotata,* histoire naturelle, menaces, viande de brousse, Nigéria

Introduction

The Two-spotted Palm Civet *Nandinia binotata*, also known as African Palm Civet and hereafter referred to as Palm Civet, is the only species of the family Nandiniidae (Gaubert 2013) and is widespread across tropical Africa, being also one of the most intensively

harvested carnivore species in the African forests (Van Rompaey & Ray 2013). Indeed, ca. 10% of all traded carnivore carcasses registered in a recent meta-analysis belonged to this species (Doughty *et al.* 2015), and Palm Civets had the second highest offtake in villages, and were the most commonly sold carnivore species in Gabon (Bahaa-el-din *et al.* 2013). This small carnivore is very well known to villagers across Africa, being a target of several traditional beliefs (*e.g*., Campbell 2009). Nonetheless, still very little is known about the ecology of this species (Charles-Dominique 1978, Emmons *et al.* 2009, Van Rompaey & Ray 2013), although it is clear that it fulfils the ecological role of a 'Carnivore-Primate', being quite arboreal and frugivorous (see Charles-Dominique 1978 for instance). It occurs in deciduous forests, lowland rainforests and mountains up to 2,500 m asl, gallery and riverine forests, savanna woodlands, logged and second-growth forests, and also in cultivation mosaics following forest clearing (Van Rompaey & Ray 2013).

In Nigeria, the Palm Civet has remained virtually unstudied, although numerous distribution records are available, especially for the southern part of the country (*e.g*., Rosevear 1953, Happold 1984, Angelici *et al.* 1999, Blench 2007, Petrozzi *et al.* 2015). However, given that the Nigerian natural environment is rapidly changing due to human development (De Montclos 1994: 186, Agbagwa & Ndukwu 2014, Petrozzi *et al.* 2015), it is likely that at least some of these recorded sites are no longer occupied. In addition, there is virtually no data on the conservation status of this elusive carnivore species in Nigeria.

Our aims with this paper are three-fold:

(1) To provide updated distribution records of *Nandinia binotata* for the south-eastern regions of the country (*i.e.*, from the Niger Delta to the Cross River State, adjacent to Cameroon):
(2) To make a preliminary analysis of habitats frequented by *Nandinia binotata* in the study region on the basis of mainly specimens sold in local bushmeat markets;
(3) To provide some conservation considerations for *Nandinia binotata* in the study region.

Materials and methods

Study areas

The study was carried out in south-eastern Nigeria, in a region ranging from the western side of the River Niger Delta eastward to the border with Cameroon. Within this region, we studied this species in three main areas:

(1) The Niger Delta swamp forests ecoregion. This region is contained in a triangle with the town of Aboh on the Niger River being the northernmost tip, the Benin River forming the western boundary of the ecoregion, and the Imo River the boundary on the eastern side. The whole area has been heavily deforested in the last 50 years (Agbagwa

& Ndukwu 2014) as a result of it being the most important oil and gas production region of Sub-Saharan Africa (De Montclos 1994). However, some patches of deltaic swamp forest remain. This swamp forest can be further subdivided into three zones based on hydrological variation (Blench 2007):

(a) The flood forest is characterized by strong seasonal variation with a few permanent creeks and lakes during the dry months, and almost completely inundated during the last phase of the rainy season.

(b) The Eastern delta flank is mainly re-growing second-growth forest and gallery forest along the banks of the Imo River.

(c) The Central back-swamp area of the delta, crossed by old creek levees, is a relatively stable area as it is not flooded and is not influenced by the tides (Blench 2007).

Along its southern side, the Niger Delta Swamp Forests are separated from the Atlantic Ocean by a band of mangroves, which can reach up to 10 km inland (Blench 2007). In front of the mangrove belt and close to the sea are ephemeral coastal barrier islands that are often clothed in transitional vegetation.

(2) The extensively deforested area in-between the Imo River in the west and the Cross River in the east (in the states of Abia and Akwa–Ibom). This region consists mostly of farmland, plantations and farm–bush mosaics, with small patches of remnant rainforest (*i.e.*, holy groves) and gallery forests along the Imo, Izumini and Kwa–Ibo Rivers.

(3) The lowland, hilly and montane rainforests situated between the River Cross and the border with Cameroon (Cross River State). This region makes up the best-preserved forest area of Nigeria. Considerable portions of the territory are covered by tall canopy forests, especially in the Ikpan Forest block (Eniang & Luiselli 2002), the Cross River National Park, and the Mbe Mountains and Afi Mountains forest blocks (Oates *et al.* 2004, Oates 2011).

The climate of the study area is characterized by a long rainy season from April through end of September. The wet season peaks in July, and the driest months are January and February. Precipitation increases from the north of the delta to the coast; from ca. 2,500 mm to ca. 4,000 mm mean annual rainfall, making this region among the wettest areas in Africa (Blench 2007). Cloud cover is nearly continuous across the year, with a mean of about 1,500 annual sunshine hours and an average annual temperature of approximately 28°C (Blench 2007).

Methods

This paper is based on original field data collected by the authors. Distribution and habitat type data from the Niger Delta region were collected between 1 January 2008 and 31 December 2014. We did not use older records in order to minimize the possibility of including sites where Palm Civets have been extirpated or where local habitat has been heavily modified in recent years. For defining population trends, especially relatively to the Cross River State, we used data recorded from December 1995.

Data were collected using (i) opportunistic field observations and (ii) more standardized surveys of bushmeat markets (Niger Delta) and forest villages (Cross River State). Field data of a few wild individuals were obtained opportunistically during surveys specifically conducted to study the community ecology of Niger Delta reptiles across forests, mangroves, bushlands, and plantations (*e.g.*, Akani *et al.* 2014a, 2015b). During these reptile-oriented surveys, data on the local mammal fauna were also collected (see Petrozzi *et al.* 2015 for detailed field methods). Bushmeat market data were obtained during (i) standardized and systematic surveys across 10 distinct markets of the Niger Delta, (ii) opportunistic surveys across many other local markets situated in Delta, Bayelsa, Rivers, Abia and Akwa–Ibom States, and (iii) long-term surveys of wildlife hunted in two forest villages in Cross River State.

The ten Niger Delta markets subjected to systematic surveys were: Swali, Mosogar, Patani, Oredo, Imo river Bridge, Omagwa, Akabuka, Ahoada, Mbiama and Eket Bridge. These markets were surveyed in order to analyze in depth (1) the trade dynamics of the various marketed species, especially chelonians and mammals (Luiselli *et al.* 2013, Akani *et al.* 2015c), and (2) the market shifts related to the Ebola virus spreading (Akani *et al.* 2015d). Markets were surveyed during both the dry season (*i.e.*, October–March) and the wet season (*i.e.*, April–September) of each year of study, but with different field effort among the various markets. Sampling in bushmeat markets was carried out only in the morning hours (7h00–11h00), when hunters land their bounties and sell them to bushmeat dealers. Animals killed in the previous night's hunting and animals trapped by snares must be brought to the market in the morning before they begin to putrefy and loose market value (Akani *et al.* 2015c). Further information on the bushmeat trade (*e.g.*, price of the animal on sale, place of capture, etc.) was acquired through interviews with the dealers and hunters. Hunters in target areas were located mainly through prior personal contacts, and, in order to test their reliability, were firstly asked to give an account of the variety of local animals (*e.g.*, using vernacular names), before asking for more details about the local abundance of the study species. Habitat data were considered only when there was no ambiguity in the responses of the interviewees, *i.e.* when, for instance, data came from surveys in small village markets, because animals sold in such small markets should come from a very short distance. A considerable portion of records was not used to address habitat data for the study species (see below), especially when data came from markets in large towns. However, it should be noted that (i) our survey effort to find Palm Civets was

not identical or precisely quantified across habitats, (ii) the species' detectability may vary across habitats, and (iii) different hunters may have reported habitat types in different ways. Thus, some biases are still possible despite our best efforts to reduce ambiguity in data records.

In Cross River State, the forest villages Ebbaken (06°17′N, 08°55′E) and Enyi (06°16′N, 08°55′E; area of Boje, Northern Cross River State) were used for assessing long-term population trends for the study species. These villages were surveyed during long-term ornithological research by one of us (PM). In these villages, the whole variety of wildlife hunted by villagers every day for about 45 consecutive days per year (during the dry season) was examined, and the total number of carcasses of each species was recorded.

Considering all the above-mentioned sources of data, it resulted that most of the specimens were recorded at bushmeat markets, with a few individuals also spotted in the wild.

Differences in absolute frequencies of animals across habitat types, and between seasons, were examined with goodness-of-fit tests and chi-square tests of homogeneity. The relationship between the succession of study years and yearly number of observed specimens was analysed using Spearman's rank correlation test. Non-parametric tests were used because the variables of interest were not normally distributed. Alpha was set at 5%. All statistical tests were performed with PAST software.

Results and discussion

Distribution

The recent distribution records ($n = 29$ sites) of the Two-spotted Palm Civet are given in Figure 1. These records include both dead specimens ($n = 73$), usually offered in local and in central (hub) bushmeat markets, and direct sightings of free-ranging individuals ($n = 8$) (Figure 2A).

Niger Delta: Our records came from a wide variety of localities, situated in Delta, Edo, Ondo, Bayelsa, and Rivers States (Table 1). Our data confirm the occurrence of the Palm Civet in five forest reserves (FRs) of Bayelsa and Rivers States (*i.e.*, Nun River, Taylor Creek, Egbedi Creek, Edumanom, and Upper Orashi FRs; see Petrozzi *et al.* 2015), as well as in the Okomu National Park, Edo State (Figure 2B). To our knowledge, this species has so far only been reported from Upper Orashi FR (Angelici *et al.* 1999) and Taylor Creek FR (Akani *et al.* 2015), whereas its presence was considered 'possible' in Edumanom based on interviews with hunters (Bocian 1999). Blench (2007) did not report any distribution record for this species in the Delta.
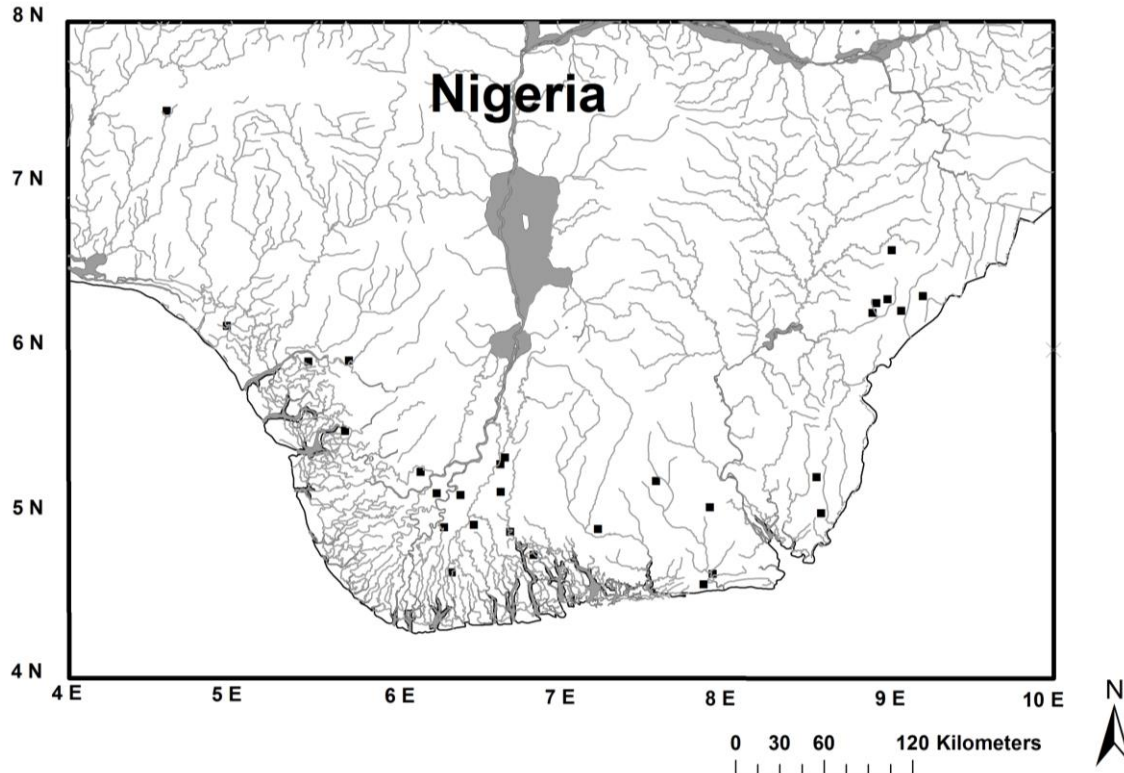
Figure 1. Map of southeastern Nigeria, showing the sites (*n* = 29) of Two-spotted Palm Civet *Nandinia binotata* records. Data inserted in this map were collected in 2008–2014, by (i) surveys in bushmeat markets, (ii) hunters' catches inspection, and (iii) field observations.

Widely deforested region between the Imo and Cross Rivers: The species showed an apparently scattered distribution in Abia and Akwa–Ibom States. In recent years, it was recorded only from the gallery forests of Imo River, at the border with Rivers State, in Stubbs Creek Forest Reserve and in the surroundings of Eket, and at Urua–Ekpa junction around Uyo, in Akwa–Ibom State (Figure 1).

Forested areas east of the Cross River: The Palm Civet was recently recorded in the Ikpan Forest block – where it was first recorded by Eniang & Luiselli (2002) – and in Cross River National Park – where it was first recorded by Reid (1997). In the latter protected area, there were recent records in both the Oban and Okwangwo Divisions, and also around Obudu in northern Cross River State. In addition, *Nandinia binotata* was also recorded in the Afi Mountains Wildlife Sanctuary and in the surroundings of the villages Ebbaken and Enyi, in the area of Boje. Presence of the species in the Afi Mountains complex area, prior to the present article, was recorded by Pimley (2003), McFarland (2007), Imong *et al.* (2009) and Oates (2009).

Altitude was not a restricting factor in the ecological distribution of Palm Civets in Nigeria, as they were recorded in lowland forests (*e.g.*, gallery forest of Imo River and second-growth forest of Upper Orashi FR) as well as in hilly and montane forests (*e.g.*,

second-growth forests of Afi Mountains Wildlife Sanctuary or second-growth forests of Cross River National Park [highest elevation = 1,318 m asl]).

Figure 2. (A) Specimens of *Nandinia binotata* offered for sale in a local bushmeat market at the Edumanom Forest Reserve, Bayelsa State (Photo: G. C. Akani); (B) A free-living adult individual from Okomu, Edo State (Photo: Okomu National Park archive); (C, D) Just-killed lactating female from Ebbaken, Cross River State (Photos: C. Ruoso).

Habitat ecology

A total of 81 individuals were recorded from southern Nigeria in the period 2008–2014 (Table 1). However, we analysed habitat data for only 50 individuals (*i.e.*, 8 field sightings and 42 dead specimens with confirmed locality of capture) due to unreliability of the interviewed sellers of the remaining individuals. Habitats in which Palm Civets were collected were significantly uneven (χ^2 = 29.4, *df* = 4, *P* < 0.0001), with higher-than-expected sample sizes being observed in second-growth forest, and lower-than-expected sample sizes in mature forests and in plantations (Figure 3).

Table 1. Records of Two-spotted Palm Civet *Nandinia binotata* in south-eastern Nigeria. Only records collected after January 2008 are included in this dataset, in order to exclude potential sites where the species has been extirpated. For instance, in Ebbaken, we included here only one specimen, whereas the total observed sample was 17 (if we include also the years 1995–2007 in the sample). The last column provides the total number of records (dead specimens and sightings), as well as the number of sightings only (in parentheses).

Locality	Longitude (East)	Latitude (North)	State	Habitat	No. records (sightings)
Imo River	7°13′9.24″	4°54′5.26″	Abia	Gallery forest	2
Ikot Ekpene	7°43′02	5°10′55″	Akwa-Ibom	Farmbush	1
Stubbs Creek Forest Reserve	7°51′56	4°34′10″	Akwa-Ibom	Second-growth forest	1
Urua–Ekpa	7°54′53.01″	5°2′19.67″	Akwa-Ibom	Farmbush	3 (1)
Ikpan Forest	8°35′	5°00″	Cross River	Mature forest	4 (1)
Cross River National Park (Oban Div)	8°33′15″	5°13′22″	Cross River	Second-growth forest	4 (1)
Cross River National Park (Okwangwo Div)	9°13′42.46″	6°21′12.16″	Cross River	Second-growth forest	2
Ethiope River	5°42′11″	5°55′35″	Delta	Gallery forest	6 (2)
Ologbo	5°27′24′	5°55′35″	Edo	Gallery forest	1 (1)
Ifetedo	4°35′33″	7°27′12″	Ondo	Gallery forest	1
Zarama–Epie	6°08′31″	5°15′11″	Bayelsa	Plantation	1
Edumanom Forest Reserve	6°13′51.1″	5°7′20″	Bayelsa	Second-growth forest	3
Taylor Creek Forest Reserve	6°23′09′–6°36′18″	5°6′25′–5°24′31″	Bayelsa	Second-growth forest	4
Egbedi Creek Forest Reserve	6°20′	4°38′49″	Bayelsa	Second-growth forest	3
Upper Orashi Forest Reserve	6°27′28″	4°55′57″	Rivers	Second-growth forest	3 (2)
Nun River Forest Reserve	4°53′57″	6°30′54″	Bayelsa	Plantation	2
Swali	6°17′	4°55′	Bayelsa	Unknown	29
Kreigeni	6°37′41″	5°17′59″	Rivers	Second-growth forest	1
Ahoada	6°39′12″	5°04′26″	Rivers	Farmbush	1
Omoku	6°39′17.30″	5°20′34.18″	Rivers	Unknown	1
Abua-Odual	6°57′	4°44′53″	Rivers	Gallery forest	1
Otari	6°41′11″	4°53′22″	Rivers	Farmbush	2
Warri	5°45′19″	5°30′54″	Delta	Unknown	1
Eket	7°55′48″	4°38′47″	Akwa–Ibom	Second-growth forest	2
Obudu	9°10″01	6°39′59″	Cross River	Unknown	1
Ebbaken	8°55′	6°17′	Cross River	Second-growth forest	1
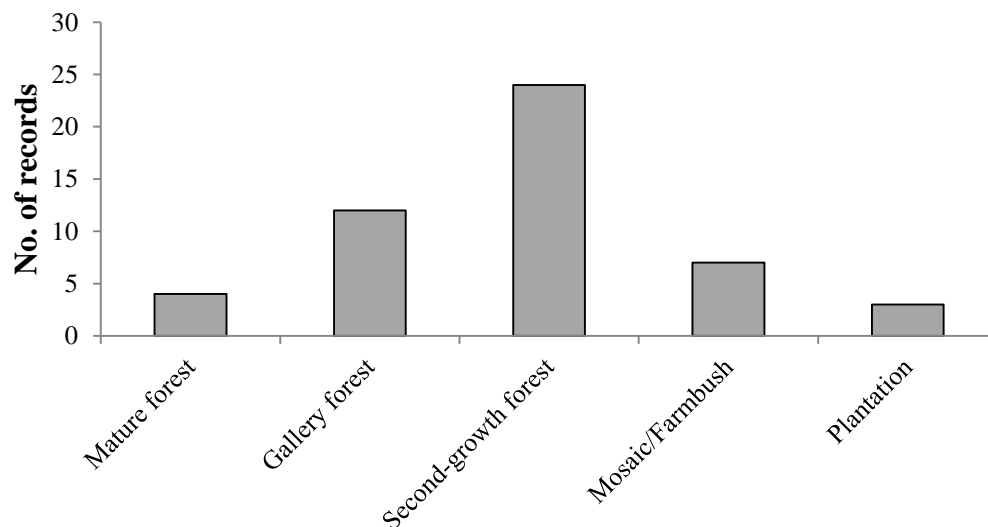
Figure 3. Absolute frequencies of habitat types in which *Nandinia binotata* was collected by hunters (*n* = 42 dead specimens) or observed by authors (*n* = 8 direct field sightings) in south-eastern Nigeria.

Our data reveal that Palm Civets are doing well in rapidly evolving forest habitats such as re-growing (even dense) forests. This was especially true for forested zones surrounded by open ecotones and savannah-like grassy margins (as is typical of gallery and riverine forests in the study region; Figure 4). Conversely, the species was apparently less easily found in more stable habitats, such as mature forests or large plantations. Overall, our data mirror the empirical observations of Van Rompaey & Ray (2013) which also consider the Palm Civet as a forest and forest–savannah–plantation mosaics habitat generalist. However, given the potential biases mentioned in the 'Methods' relating to habitat type records, it is possible that the relative frequency of occurrence of Palm Civets in mature forests may have been underestimated under our sampling regime. As the bulk of our data came from bushmeat market surveys, we could not exclude the possibility that relative frequency of habitat types actually reflects differential survey efforts by hunters instead of true species-specific ecology. In addition, it is also possible that interviewed hunters may recall more the hunting activities from second-growth forest than in mature forests (or prefer to say so) because they are afraid to be blamed for hunting in the mature forest.

Seasonality of records

In the Niger Delta, Palm Civets were recorded slightly more often during the wet season (58.5% of the total sample, $n = 65$), with no significant inter-seasonal difference ($\chi^2 = 1.86$, $df = 1$, $P = 0.241$). Sample sizes from the other areas of Nigeria were too small for performing any statistical analyses.
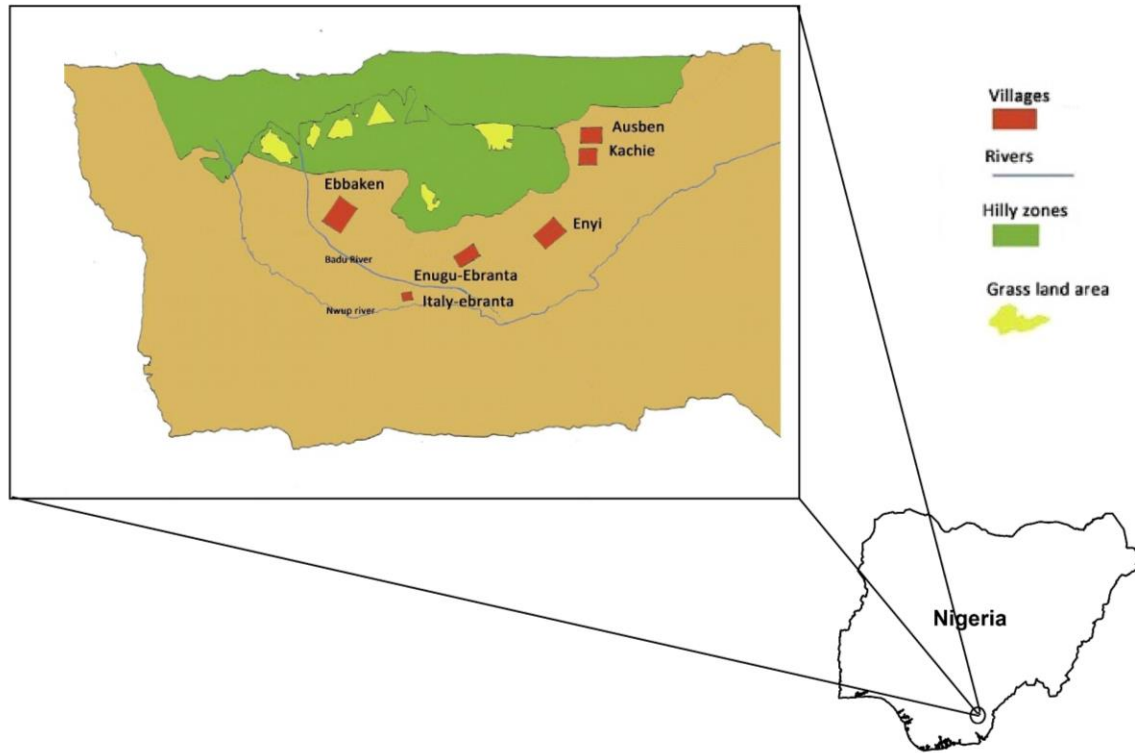
Population trends

Nandinia binotata was never subjected to demographic population studies in Nigeria, thus its population trends remain entirely unknown. However, we collected, at least for an area of the Cross River State, empirical long-term evidence of population trends. Indeed, we monitored the number of animals hunted in Ebbaken and Enyi villages during about 45 dry-season field days per year from 1995 to 2014 (Figure 5). There was a statistically significant negative trend in the yearly number of observed specimens ($r_s = -0.513$, $n = 20$, $P = 0.021$), and there was not any single individual recorded since 2010 (Figure 6), despite the fact that the number of field days was similar across years.

This pattern may suggest antithetic trends, *i.e.* that the species is either (i) locally extirpated or nearly so, or even (ii) not declined at all. In this latter case, instead, the disappearance of this species from markets would be explained by the presumed collapse of hunting activities in the Afi Mountains complex due to intensified patrolling and enhanced management by the Wildlife Conservation Society (Calabar). Thus, it is still unclear whether the observed pattern is really due to increased threats or, instead, to increased conservation. In the case that the observed decline in collected specimens is due to

increased threats, it is unlikely as a result of habitat loss, as the second-growth forest in the study area has apparently not been altered since 2000 (P. Micheloni, unpublished data). However, there was large-scale bushmeat trade before the year 2000 that may have, in part, compromised the populations of *Nandinia binotata*. In addition, this species was utilized as 'ju-ju' food (*i.e.*, traditional food supposedly favouring good luck) before a local fight between the villages of Boje and Nsadop (October 2010; Boniface Oban, villager working in the area, personal communication 2011), and hence, a comparatively high number of individuals were certainly killed for traditional ethnic reasons, thus presumably threatening the local population.

Figure 4. Second-growth swamp forest and gallery forest habitats of *Nandinia binotata* in the Niger Delta. (A) Surroundings of Port Harcourt, Rivers State; (B, C) Ethiope River, Delta State (Photos: L. Luiselli).

Figure 5. Map of the hilly forest area surrounding the villages of Ebbaken and Enyi, in the area of Boje (Northern Cross River State), where long-term population trends of *Nandinia binotata* were recorded during the years 1995–2014.
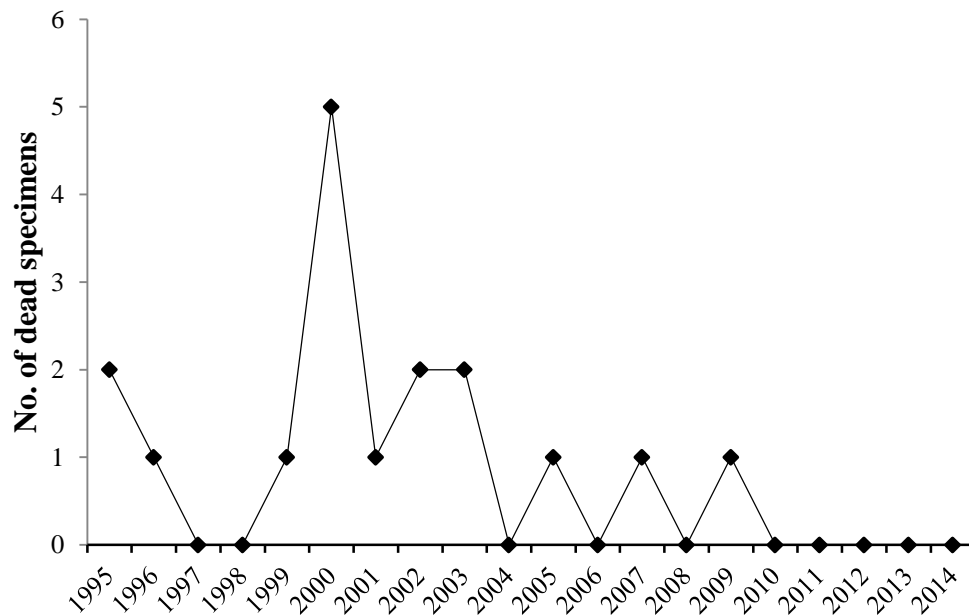
Figure 6. Long-term population trend of *Nandinia binotata* at the forest area surrounding the villages of Ebbaken and Enyi, in the area of Boje (Northern Cross River State), based on about 45 days per year of bushmeat-market monitoring.

Conservation considerations

There appear to be substantial differences in the relative abundance of the study species in the three main study areas analysed in the present paper. The Two-spotted Palm Civets is widespread throughout the Niger Delta (Figure 1), but is usually reported to be uncommon or even very rare by hunters and local people (Petrozzi *et al.* 2015). This assertion may be due to the elusive habits of this nocturnal carnivore, at least in some sectors of the surveyed area. Among 157 carnivore carcasses recorded in Swali market (Bayelsa State) over a six-month period, *Nandinia binotata* accounted for 18.5% of the specimens (total number of traded species, *n* = 5), and was the second most frequently traded carnivore species after Flat-headed Cusimanse *Crossarchus platycephalus* (Akani *et al.* 2015c). Thus, considering that Swali market collates animals hunted in a wide number of sites in Bayelsa and adjacent Rivers State, it is possible that the species is instead still common and not under immediate threat at the regional scale. Large volumes of intake do not necessarily mean that the population is healthy, as often, intakes reach their highest peak before crashing (*e.g.*, trends with marine fishes). Nonetheless, an eventual loss of gallery forest habitats may cause decline in the local abundance of *Nandinia binotata*. In the rest of the Delta, we have much less data despite strong field effort since 1996, suggesting that the abundance of this species is lower than in Bayelsa State.

The study species appears less abundant in Cross River State, and especially in Akwa–Ibom and Abia States. Hunters selling bushmeat in markets of these two states, interviewed by us during 2012–2014, congruently reported that this species is now currently uncommon, and more so now than 10 or more years ago. Unfortunately, we do not have any data that can be useful to verify this assertion (but see above for apparent population trends in a local forest area). In addition, *Nandinia binotata* was never filmed by camera-traps randomly placed for gorilla surveys in Afi Mountains Wildlife Sanctuary. Nonetheless, night calls of this species were reportedly frequently heard even in recent years in the surroundings of former Kelly camp (now Afi base camp), Afi Mountains (Emmanuel Bassey, Wildlife Conservation Society, Calabar, Nigeria, unpublished information).

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ORIGINAL ARTICLE

A diurnal observation of Small-toothed Palm Civets *Arctogalidia trivirgata* mating in Seima Protection Forest, Mondulkiri province, Cambodia

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Abstract.

Small-toothed Palm Civet *Arctogalidia trivirgata* is both nocturnal and arboreal making chance encounters with this species very rare. This species typically eludes conventional biodiversity survey techniques such as ground-based camera trapping. Small-toothed Palm Civet breeding behaviour has not been recorded in the wild and this paper describes a chance observation of mating between two Small-toothed Palm Civets in evergreen forest in eastern Cambodia.

Keywords: breeding behaviour, copulation, evergreen forest, Civet

Small-toothed Palm Civet *Arctogalidia trivirgata* is found across South-east Asia, southern China and North-east India (Corbet & Hill 1992) and is currently listed as Least Concern on the IUCN Red List of Threatened Species (IUCN Red List 2015). The majority of the records for this species are in evergreen and semi-evergreen forests (Walston & Duckworth 2003, Gray *et al.* 2014, Kakati & Srikant 2014). The species has also been recorded in *Melaleuca cajuputi*-dominated peat swamp forest (Willcox *et al.* 2012). However, because of its nocturnal and mainly arboreal habits (Duckworth & Nettelbeck 2008) this civet species has been less studied compared to some of its counterparts, as it evades conventional biodiversity survey techniques such as ground-level camera trapping (Willcox *et al.* 2012). The species was recorded in Cambodia for the first time during spotlighting surveys in 2003 in Seima Protection Forest, Mondulkiri province (Walston & Duckworth 2003), yet it has eluded larger scale surveys (Walston *et al.* 2001) and camera trapping in the same landscape (Gray *et al.* 2014). This paper describes a chance encounter of two Small-toothed Palm Civets mating in the wild; the first known record of this behaviour for this species.

Seima Protection Forest (SPF) is located in eastern Cambodia (Figure 1) and is comprised of evergreen, semi-evergreen, deciduous dipterocarp, and mixed deciduous forest (FA 2007) and ranges in elevation from 60–750 m asl. The site has a tropical monsoonal climate with a distinct wet season from May to October and a dry season from

November to April. The mean annual rainfall is 2,200 to 2,800 mm, with the majority falling during the wet season (Evans *et al.* 2013). SPF has a high biodiversity (Walston *et al.* 2001) and is home to globally important populations of endangered mammal species such as Yellow-cheeked Crested Gibbon *Nomascus gabriellae* and Black-shanked Douc Langur *Pygathrix nigripes* (Nuttall *et al.* 2013). SPF lies both within the Indo-Burma Hotspot (Tordoff *et al.* 2007) and the Lower Mekong Ecoregion Complex (Baltzer *et al.* 2011) and still contains large areas of near intact habitat (Evans *et al.* 2013). The main threats facing the forest and its biodiversity are forest clearance for economic land concessions (primarily rubber plantations), small-scale agricultural expansion by local communities, hunting, and illegal logging for luxury grade timber species (Evans *et al.* 2013).
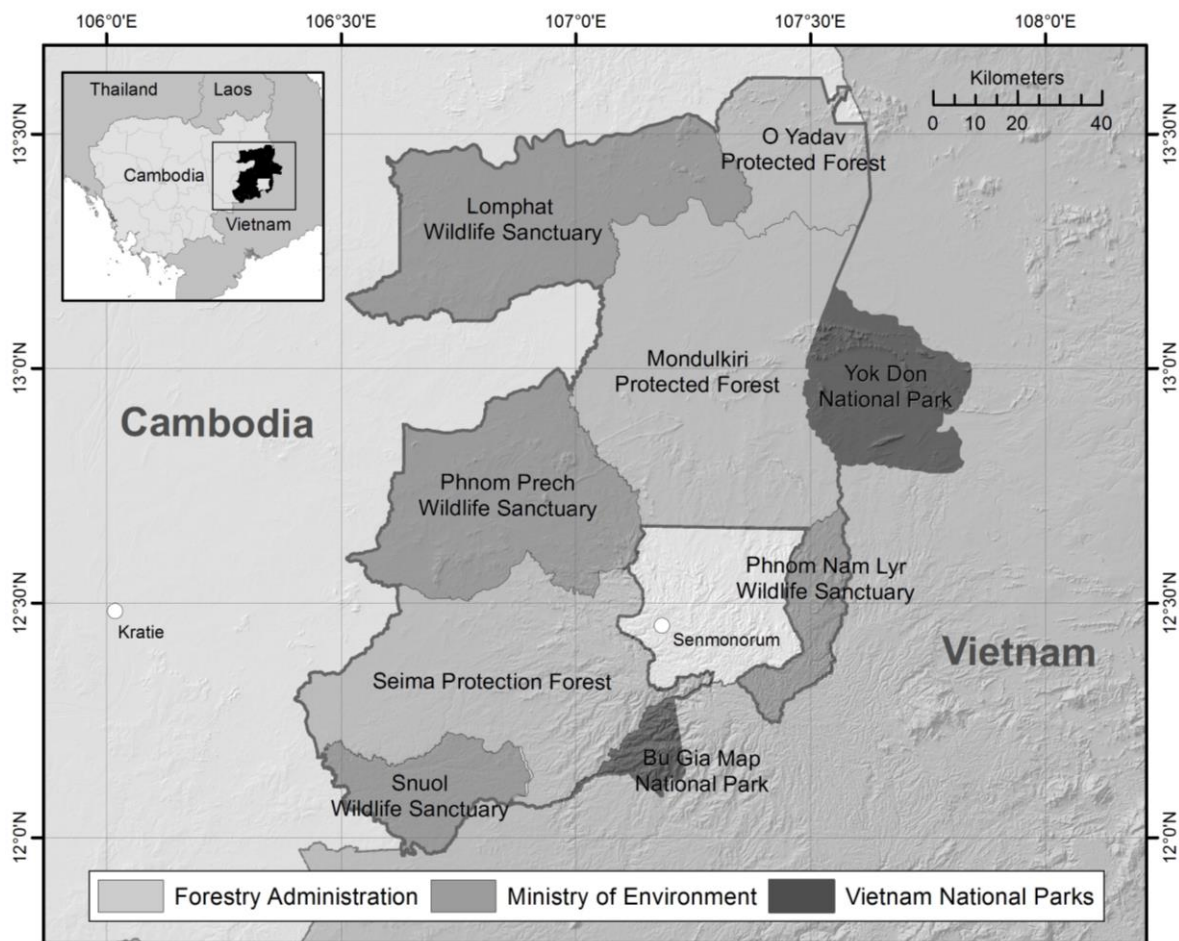
Figure 1. Map of protected areas in eastern Cambodia, and three contiguous protected areas in Vietnam. Seima Protection Forest is located in the bottom centre of the map.

Civets are a target taxonomic group for hunters in the area, with a high proportion of law enforcement confiscations of Common Palm Civet *Paradoxurus hermaphroditus*. There are no known records of Small-toothed Palm Civet being confiscated by enforcement staff within SPF. Snare removal activities within SPF removed a total of 561 snares

between May and September of 2015. Earlier studies have shown that snaring intensity within SPF is particularly high in the evergreen forest, along the Cambodia–Vietnam border and close to human settlements (O'Kelly 2013).

On 20 February 2015, BB and a local research assistant heard and then spotted two Small-toothed Palm Civets commencing intercourse approximately 8 m above the ground in the thick foliage of a small tree (provisionally identified as *Irvingia malayana*). The observation was made in an area of near pristine evergreen forest (12° 19′ 15″ N, 107° 4′ 2″ E, 430 m asl), along an old logging route, and about 1 km from the closest village. This area is believed to have relatively low hunting pressures as it is frequently used by local and foreign researchers for the habituation of two gibbon groups. Small-toothed Palm Civets are known to be nocturnal, however the encounter happened at 09h30 in broad daylight and both animals appeared to be active. Copulation was dictated by the male who, using both his teeth and front legs, subdued the female before thrusting aggressively for 10 to 20 seconds. This was repeated with breaks of about 1 to 2 minutes (Figure 2) between copulation bouts for about 30 minutes. The very aggressive nature of the mating was evident from the start with the female emitting loud hisses when approached and the male used its teeth to grab the female's neck. Similar behaviour was described for the Masked Palm Civet *Paguma larvata* in Bangladesh (Al-Razi *et al.* 2014). The act appeared to subdue the female for a short period of time allowing the male to proceed with the copulation bout. Although both individuals were aware of our presence, the animals did not disperse or stop their copulating. Once the act was over the female curled up and appeared to fall asleep whilst the male remained awake (Fig. 3), repeatedly checking us, until finally falling asleep next to its mate.

Notwithstanding the paucity of records for this species it may be more common than it was believed to be (Willcox *et al.* 2012). Diurnal observations of the species have been accidental, and considering its primarily nocturnal and arboreal behaviour, the best way to monitor local and regional populations may be using spotlighting at night, as has been suggested by Walston & Duckworth (2003). The species is not threatened compared to other small carnivores in mainland South-east Asia and is not considered to be a conservation priority (Willcox *et al.* 2012). Here we describe an insight into the breeding habits of this civet species. Further research is needed to elucidate the Small-toothed Palm Civet's behavioural ecology, including feeding, sociality, and rearing of the young.

Figure 2. The two Small-toothed Palm Civets *Arctogalidia trivirgata* at rest in the dense canopy after a copulation bout, Seima Protection Forest, Cambodia, February 2015 (Photo: B. Barca, WCS Cambodia).

Figure 3. The male Small-toothed Palm Civet at rest after copulation, Seima Protection Forest, Cambodia, February 2015 (Photo: B. Barca, WCS Cambodia).

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

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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*, la 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).
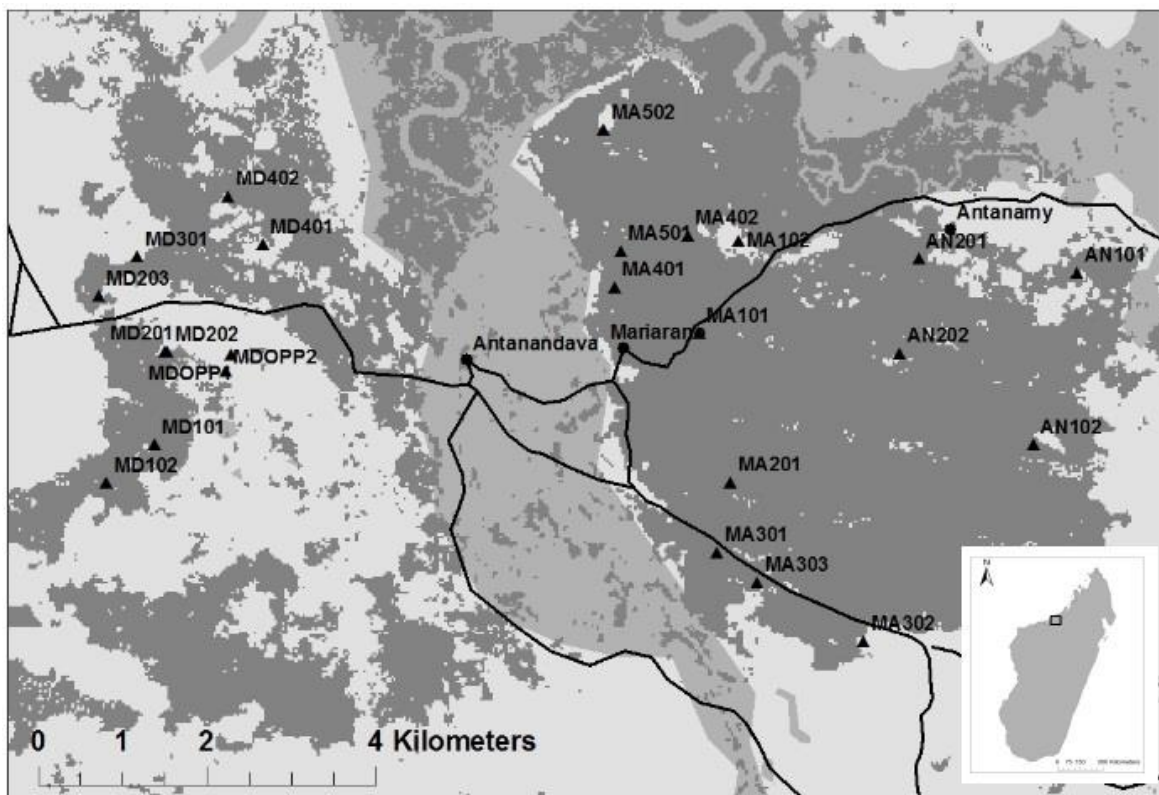
Figure 1. Map of the study area showing the position of the study area in Madagascar (inset), and locations of camera stations used in 2014. Forest patches are indicated by dark grey, intermediate-grey areas are wetland and riverine areas, while light grey represents open savannah areas with little tree 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 (± SD) trap nights (± 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	*C. familiaris* (5)
MA102	15°28′06″	46°42′18″	0	Camera stolen
MA201	15°29′36″	46°42′18″	33	*F. catus* (1)
MA301	15°30′06″	46°42′42″	31	*E. major* (2), *C. familiaris* (5), *F. catus* (2)
MA302	15°30′3″	46°43′12″	31	*E. major* (2), *V. indica* (2), *C. familiaris* (1)
MA303	15°30′18″	46°42′30″	31	*C. ferox* (1), *V. indica* (3), *F. catus* (1), *C. familiaris* (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	*F. catus* (2), *C. familiaris* (1)
AN102	15°29′24″	46°44′18″	31	*E. g. major* (2), *V. indica* (1), *F. catus* (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	*F. catus* (3), *C. familiaris* (1)
MD201	15°28′48″	46°38′36″	24	*F. catus* (3)
MD202	15°28′48″	46°38′36″	24	*F. catus* (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	*V. indica* (1), *F. catus* (4)
MDOPP1	15°28′48″	46°39′00″	24	*V. indica* (2), *F. catus* (1), *C. familiaris* (1)
MDOPP2	15°28′54″	46°39′00″	4	*V. indica* (2)

[1]Effort 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.
[2]The 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 *Cryotoprocta 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 are 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 km^2 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

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The conservation status of small carnivores in the Ke Go – Khe Net Lowlands, Central Vietnam

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Abstract.

The Ke Go – Khe Net Lowlands are one of the largest remaining tracts of lowland evergreen forest in central Vietnam. Based on confirmed records and predicted distribution, the landscape was identified as a priority for small carnivore conservation, including for the Vulnerable (*sensu* IUCN Red List of Threatened Species) Owston's Civet *Chrotogale owstoni*. Targeted small carnivore surveys using camera trapping and spotlighting were undertaken in 2006, 2007 and 2010. Despite a relatively high survey effort of 1,171 effective camera-trap nights and 101 hours of spotlighting, only six small carnivore species were confirmed, none of which is considered a priority for conservation even at the national level. These survey results evidence a landscape where a wide range of animal taxa, including small carnivores, are either locally extinct or significantly declined in population. At a regional level, the priority conservation action must be to secure sites in the Annamese Lowlands that have not yet acquired the Ke Go – Khe Net Lowland's faunally impoverished status, and for which there is a possibility of successfully conserving a range of Annamese endemics and lowland species in-situ. Forested areas along the Quang Binh – Quang Tri provincial border are probably the priority sites, particularly Khe Nuoc Trong in Quang Binh province.

Keywords: camera trapping, conservation priorities, habitat use, lowland forest

Introduction

Vietnam lies on the eastern border of mainland South-east Asia and is a global priority for biodiversity conservation (Olson & Dinerstein 1998, Stattersfield *et al.* 1998, Myers *et al.* 2000, Brooks *et al.* 2002, 2006, CEPF 2012). Vietnam has been identified as a core country for small carnivore conservation (Schreiber *et al.* 1989). There are 23 small carnivore species recorded in Vietnam (Roberton 2007).

The key threats facing Vietnam's biodiversity include the loss and degradation of natural habitats, and the overexploitation of wildlife and plants for sale into the illegal wildlife trade (Sodhi *et al.* 2004, Sterling *et al.* 2006, CEPF 2012, Brook *et al.* 2014). Small carnivores represent one of the largest proportions of the wildlife trade in Vietnam (Bell *et al.* 2004, Roberton 2007). Although there are reports of small carnivores in the traditional

medicine trade, pelt trade and pet trade, the primary demand for small carnivores comes from consumption in wild meat restaurants across Vietnam and in in the adjacent country of China (Bell *et al.* 2004).

Central Vietnam contains a range of diverse and endemic mammalian taxa, forming part of the Greater Annamites Ecoregion which consists of the Annamite mountain range, associated foothills and the Annamese Lowlands (Baltzer *et al.* 2001, Sterling *et al.* 2006, CEPF 2012). The Ke Go – Khe Net Lowlands supports one of the largest remaining areas of lowland evergreen forest in the Annamese Lowlands (BirdLife International 2015a, 2015b). A number of globally threatened animal species have been recorded from the landscape, including Ha Tinh Langur *Trachypithecus hatinhensis*, Gaur *Bos gaurus*, Large-antlered Muntjac *Muntiacus vuquangensis* (sometimes referred to as *Megamuntiacus vuquangensis*; *e.g.*, Le Trong Trai *et al.* 1999), White-winged Duck *Asarcornis scutulata* and Vietnamese Pheasant *Lophura hatinhensis* (Eames *et al.* 1994, Le Trong Trai *et al.* 1999, 2001). Vietnamese Pheasant is no longer considered a valid species and is now thought to be a variant of the Critically Endangered Edwards' Pheasant *Lophura edwardsi* (Hennache *et al.* 2012).

In the 1990s the Ke Go – Khe Net Lowlands received significant international attention through the rediscovery of 'Vietnamese Pheasant', an Annamese endemic (Robson *et al.* 1993, Eames *et al.* 1994). The site has since been surveyed for its general biodiversity, with a focus on bird species (Le Trong Trai *et al.* 1999, 2001; although both of these reports include records originally described in Robson *et al.* 1993 and Eames *et al.* 1994) and more recently for Nomascus gibbons (Van Ngoc Tinh *et al.* 2010).

There have been 14 small carnivore species reported in interviews from the Ke Go – Khe Net Lowlands including Binturong *Arctis binturong*, Spotted Linsang *Prionodon pardicolor* and Eurasian Otter *Lutra lutra* but, prior to the survey described herein, only had been six confirmed (through reliable field observation, camera trap photographs or identifiable remains) records (Roberton 2007). Small carnivore records based on interview data are extremely unreliable and should not be considered confirmed records or, often, even worthy indications of presence; local names for a single 'species' can also be used to describe an entire taxonomic group (*e.g.*, civets), or even two very different species (*e.g.*, Fishing Cat *Prionailurus viverrinus* and Large-spotted Civet *Viverra megaspila*; Holden & Neang 2009).

The confirmed records comprise Crab-eating Mongoose *Herpestes urva*, Small Asian Mongoose *H. javanicus*, Yellow-throated Marten *Martes flavigula*, ferret badger *Melogale¿* sp., Asian Small-clawed Otter *Aonyx cinereus* and Yellow-bellied Weasel *Mustela kathiah* (Le Trong Trai *et al.* 1999, 2001, C. Robson pers. comm. in Roberton 2007). Roberton (2007) highlighted the area as a priority for small carnivore conservation, as it contained apparently suitable habitat for a number of globally threatened small carnivore species,

including the Vulnerable (*sensu* IUCN Red List) Owston's Civet *Chrotogale owstoni*, a species, indeed genus, known only in Lao PDR, Vietnam and south China (Schreiber *et al.* 1989).

This paper summarises the records obtained during targeted small carnivore surveys in the Ke Go – Khe Net Lowlands during 2006, 2007 and 2010.

Materials and methods

Study area

Covering approximately 48,000 ha, the Ke Go – Khe Net Lowlands is one of the largest remaining patches of Wet Evergreen Forest (*sensu* Rundel 2009) in the Annamese Lowlands (BirdLife International 2015a, 2015b). The landscape comprises two contiguous sites: Ke Go Nature Reserve [NR] in the north (18° 05′ N, 105° 59′ E) and Khe Net proposed NR in the south (18° 02′ N, 105° 58′ E).

A 1996 survey of Ke Go NR classified vegetation types into four broad categories based on the level of human impact: lightly disturbed broadleaf evergreen forest; heavily disturbed broadleaf evergreen forest; plantation; and scrub and grassland (see Le Trong Trai *et al.* 1999). Commercial tree species are selectively logged from lightly disturbed broadleaf evergreen forest, but much of this vegetation type remains little changed. Heavily disturbed broad-leaved evergreen includes areas that have been completely cleared and are now secondary forest, and some areas that have managed to retain some plant species and structure associated with primary forest, despite heavy anthropogenic disturbance. Approximately 74% of Ke Go NR was classified as heavily disturbed broadleaf evergreen forest, with only the more inaccessible steep slopes and hill tops retaining some of the least anthropogenically disturbed forest (Le Trong Trai *et al.* 1999). No equivalent published figures on habitat quality exist in English for Khe Net proposed NR, but, based on direct observation, the site contains similar habitat types and shows similar patterns of human-induced disturbance; all accessible lowland areas are now mostly secondary forest and retain few large (over 15 m high) trees. At the edges of southern extent of the landscape there are eucalyptus and rubber plantations. A network of permanent rivers and streams dissects this landscape.

The topography of the Ke Go – Khe Net Lowlands is undulating hills, not reaching over 500 m. The wet season is characterised by regular rainfall and extends from August to October, with an annual rainfall of 2,200 mm to 2,900 mm. From November to March the area experiences a dry season with very little rain. Temperature ranges from an average of 25 °C in July to 11 °C in January.

There were approximately 50,000 people living in the buffer zone of Ke Go – Khe Net Lowlands in 1999 of mainly Kinh ethnicity (who comprise the majority ethnic group in Vietnam) with small numbers of Muong and Nguon minority groups (Le Trong Trai *et al.* 1999, 2001). Many of these households undertake activities that are threats to the landscape which include hunting, timber extraction, firewood collection, and oil extraction from *Cinnamomum parthenoxylum* and other trees of the family Lauraceae (Le Trong Trai *et al.* 1999, 2001).

Methods

Field survey methods

Four methods were used to obtain small carnivore field records: diurnal searches for tracks and signs, live trapping, nocturnal spotlighting walks and camera trapping.

Field surveys were conducted in the Ke Go – Khe Net Lowlands intermittingly from October to March 2007 and then again from January to May 2010. The 2006 survey was conducted in the lower-elevation areas, often near some of the major streams and rivers in Ke Go-Khe Net Lowlands. The 2010 survey focused on the hill range that runs between Ke Go NR and Khe Net proposed NR; the majority of this hill range is in the former.

Night-spotting and diurnal walks

Human-made pathways were followed in the forest for both diurnal and night walks (see Duckworth 1998). Trails were selected that passed through both secondary and primary forest, with relatively little time spent in plantations, grassland or scrub areas. Night-spotting was conducted once along the banks of the Ke Go Reservoir (approximately 3,000 ha) from a boat. The habitat on the banks of the reservoir is highly degraded and has been completely cleared in many places, with grasses and other low-lying vegetation (less than 1m high) dominant.

LED head-torches were used to detect the eye shine of mammals by scanning trees and other vegetation along the main trails, in addition to along the trail itself (see Duckworth 1998). A number of globally threatened small carnivore species give a strong eye-shine and are detectable using this method (*e.g.*, Mathai *et al.* 2013: Table 1), including Owston's Civet *Chrotogale owstoni* (Duckworth 1997). When eye-shine was detected, a stronger (approximately two million candle-power) spot-light was used to help confirm the identity of the species. If far from the edge of the pathway or obscured by vegetation, binoculars were used to assist identification.

Weasel live-trapping

Single-door humane traps $10 \times 10 \times 50$ cm (locally made using stainless steel, similar in style to a Tomahawk single-door trap) were used to target weasels *Mustela* sp., as this

taxonomic group is very difficult to record using camera traps or by direct observation. Twelve traps were set within Ke Go Nature Reserve from 17 to 22 October 2006 and checked on subsequent mornings. Baits for the traps contained Hawbaker's weasel lure and beef sausage. Commercially available weasel lures were used as it was thought they might aid the survey; none of the lures used have a proven efficacy for attracting South-east Asian forest weasels.

Table 1. Small carnivore species recorded in Ke Go – Khe Net Lowlands, October 2006 – March 2007 and January – July 2010.

Common Name	Scientific Name	Record Type	m asl	Habitat Type	Date	Time
Stripe-backed Weasel	*Mustela strigidorsa*	CT	130	SEF	Oct06	night-time*
Yellow-throated Marten	*Martes flavigula*	O	100	SEF	14Oct06	15h10
		CT	100	SEF	3Nov06	15h03
		C	n/a	n/a	9Nov06	n/a
		CT	150	SEF	28Jan07	night-time*
		CT	300	HD-EF	8Jun10	22h31
Ferret badger	*Melogale* sp.	CT	300	LD-EF	22May10	night-time*
		CT	300	LD-EF	14Jun10	night-time*
		CT	300	LD-EF	2010	night-time*
		CT	300	LD-EF	1Jun10	19h58
Large-toothed Ferret Badger	*Melogale personata*	R	n/a	n/a	7Mar10	n/a
Large Indian Civet	*Viverra zibetha*	O	50	EP	25Oct06	21h50
		O	100	SEF	14Nov06	21h34
		O	100	SEF	15Nov06	19h45
Common Palm Civet	*Paradoxurus hermaphroditus*	C	n/a	n/a	9Nov06	n/a
		CT	220	SEF	20Nov06	night-time*
		CT	235	LD-EF	12Jun10	21h51
		O	300	LD-EF	18Mar10	20h00
Small-toothed Palm Civet	*Arctogalidia trivirgata*	O	150	SEF	26Mar10	20h10
		O	160	HD-EF	28Apr10	21h30

Notes: Record Type: O = Directly observed, CT = Camera trapped, R = Remains
Habitat: SEF = Secondary evergreen forest, LD-EF = Lightly disturbed lowland evergreen forest, HD-EF = Heavily disturbed lowland evergreen Forest, EP = Eucalyptus plantation
All elevations were recorded using a GPS and are therefore approximate
* = time not recorded on the camera trap unit

Camera trapping

Over the 2006–2007 survey period, eleven DeerCam DC 300 camera traps loaded with ISO 200 film and were set at eleven camera trap stations, all within secondary habitats.

Four DeerCam DC 300 (with ISO 200 film), nine Cuddeback Capture, one Cuddeback Excite and one Bushnell Trophy Cam (all three models are digital) were set during 2010. All of these camera traps were set along the near intact evergreen forest that runs along the hill range that forms the border between these two sites.

The following settings were applied to all camera traps in both 2006 and 2010. Fifteen second delay between photographs for non-digital cameras and 30-second delay for digital cameras (except for the one Bushnell Trophy Cam which had a 15-second delay, and the Cuddeback Excite which had a 60-second delay) and with the trigger sensor at high/auto-high sensitivity. Cameras were set 20–30cm from the ground to maximise the possibilities of successful detection (most small carnivore species have a shoulder height of

below 30 cm), and pointed either North or South to avoid over/under exposure. Any vegetation was removed from a 3 m zone in front of the camera trap to increase the sensor's ability to detect the target species and to avoid vegetation preventing successful identification; this perhaps reduces the chance of finding linsangs *Prionodon* and weasels (see Chutipong *et al.* 2014). In 2010 the digital cameras also had stainless steel cases designed to help reduce theft/tampering and rainwater penetration. All cameras were checked every 30 to 45 days and a new 36 exposure film inserted and if digital, memory cards replaced.

Natural baits and commercially available artificial lures were used to attract small carnivores to a camera trap's detection zone. Fixed distances of 2.5 to 3m were set between the camera trap and a 'target log'. Baits and/or artificial lures were then applied to these 'target logs', including Hawbaker's weasel lure, Hawbaker's wild cat lure, Kishel's crossbreed lure, Kishel's weasel lure, dried fish, shrimps, honey, fish oil, raw duck egg, beef sausage and/or shredded fish. Details for all camera trap stations are in Table 2.

Results

Field surveys covered all major habitat types, with particular focus on the lightly and heavily disturbed lowland evergreen forest that was described in Le Trong Trai *et al.* (1999), with less time in plantations, scrub, secondary forest, and grassland. In total, the survey team conducted approximately 101 hours of night-spotlighting (59 hours in Ke Go NR and 42 hours in Khe Net proposed NR), and 81 hours of diurnal sign surveys (49 hours in Ke Go NR and 32 hours in Khe Net proposed NR). In addition 12 traps were laid for a total of 42 trap-nights for weasels. A total of 1,171 camera trap nights was conducted from 22 October 2006 to 24 March 2007 and 23 January to 7 July 2010. Eight of the camera traps either failed or were stolen, reducing the survey effort using this method.

In total there were 19 small carnivore records, with six species confirmed for the landscape: Stripe-backed Weasel, Large-toothed Ferret Badger, Yellow-throated Marten, Large Indian Civet, Common Palm Civet and Small-toothed Palm Civet (Table 1). Thirteen other mammal species were recorded during the survey; none is globally threatened (Table 3). Domestic dog *Canis familiaris* and local people were regularly recorded on camera traps and by direct observation, often well within the core zone of the landscape. The live-trapping only produced one mammal record: an unidentified squirrel *Callosciurus* sp. Sign surveys cannot produce species level records for small carnivores unless verified by other means (*e.g.*, DNA analysis of scats); however, they can provide a useful preliminary indication of the conservation status of small carnivores in general, and for directing camera trap placement and spotlighting. There were no sign or track records collected during the surveys, providing further evidence of a small carnivore community with depressed populations.

Table 2. Camera-trap effort for recording small carnivore species in Ke Go – Khe Net Lowlands, October 2006 – March 2007 and January – July 2010.

Site	m asl	Lat Long	Artificial lure and bait	Microhabitat	Date set	Trap days	Small carnivores	Other mammals	Disturbances
KGNR	130	18° 06′ 01″ N 105° 51′ 42″ E	Hawbaker's Weasel lure, dried fish & shrimps, sausage, fish oil, honey	n/a	22Oct06	153	Stripe-backed Weasel *Mustela strigidorsa*	Northern Treeshrew *Tupaia belangeri*	Domestic dog
KGNR	100	18° 06′ 21″ N 105° 56′ 26″ E	Hawbaker's Weasel lure, dried fish & shrimps, one duck egg, sausage	n/a	27Oct06	95	Yellow-throated Martin *Martes flavigula*	Lesser Oriental Chevrotain *Tragulus kanchil*	
KNpNR	120	18° 02′ 29″ N 105° 55′ 36″ E	Hawbaker's Weasel lure, dried fish, fish oil, sausage, honey	n/a	14Nov06	125		Northern Pig-tailed Macaque *Macaca leonina*	Local Person
KNpNR	230	18° 02′ 12″ N 105° 55′ 14″ E	Hawbaker's Weasel lure, dried fish, sausage	n/a	14Nov06	37	Common Palm Civet *Paradoxurus hermaphroditus*	Northern Treeshrew	
KNpNR	170	18° 02′ 49″ N 105° 56′ 02″ E	Hawbaker's Weasel lure, dried fishes, fish oil, sausage, honey	n/a	15Nov06	87		Northern Pig-tailed Macaque, Northern Treeshrew, Red-cheeked Squirrel *Dremomys rufigenis*	Local Person
KNpNR	200	18° 02′ 25″ N 105° 56′ 27″ E	Hawbaker's Weasel lure, dried fish, fish oil, sausage, honey	n/a	15Nov06	125		East Asian Porcupine *Hystrix brachyura*, Northern Treeshrew, Red-cheeked Squirrel, Pallas's Squirrel *Callosciurus erythraeus*	Local Person
KNpNR	150	18° 06′ 02″ N 105° 51′ 56″ E	Hawbaker's Weasel lure, dried fish, fish oil, sausage, honey	n/a	27Jan07	55		Northern Treeshrew	
KNpNR	150	18° 02′ 13″ N 105° 55′ 56″ E	Hawbaker's Weasel lure, dried fish, fish oil, sausage, honey	n/a	25Jan07	55	Ferret badger *Melogale*	Northern Pig-tailed Macaque, Northern Treeshrew	
KGNR	420	18° 08′ 05″ N 105° 53′ 22″ E	Hawbaker's Wildcat No. 2	Set facing a tree that had fallen over naturally and had started to rot	23Mar10	48		Macaque, Red-cheeked Squirrel, Pallas's Squirrel	
KGNR	360	18° 07′ 03″ N 105° 54′ 49″ E	Kishel's Weasel lure	One large (>20 m) tree within 7 m. No nearby animal/man-made trails. 5 m uphill from a small rocky gully	27Apr10	13		Macaque	
KGNR	410	18° 07′ 28″ N 105° 55′ 01″ E	Hawbaker's weasel lure	Along the main man-made pathway that ran along a hill ridge line	12May10	55		Northern Pig-tailed Macaque, Black Giant Squirrel *Ratufa bicolor*	Local Person
KGNR	300	18° 07′ 25″ N 105° 54′ 53″ E	Hawbaker's Wildcat No. 2	Pointed at a series of thick lianas, no shrub layer. Substrate dotted with rocky outcrops. <10 m from a main trail. Within 5m of Small-toothed Palm Civet sightings	27Apr10	70	Ferret badger	Northern Pig-tailed Macaque	
KGNR	300	18° 06′ 00″ N 105° 55′ 56″ E	Hawbaker's Wildcat No. 2	Rocky outcrop, thick creepers and dense shrub layer. <4 m from an animal trail	5May10	59	Ferret badger		
KGNR	240	18° 06′ 02″ N 105° 55′ 59″ E	Hawbaker''s weasel	Rocky outcrop, fruiting plants (*Syzygium*) nearby, evidence of mammals in the area (Wild Pig faeces). Within 2 m of an animal trail	5May10	60	Common Palm Civet	Asian Brush-tailed Porcupine *Atherurus macrourus*, Stump-tailed Macaque *Macaca arctoides*, Northern Pig-tailed Macaque	
KGNR	260	18° 08′ 35″ N 105° 53′ 35″ E	Kishel's Weasel lure	Set adjacent to a small man-made pathway, <50 m from a stream	9May10	54		Northern Pig-tailed Macaque	
KNpNR	300	18° 03′ 32″ N 105° 57′ 31″ E	Hawbaker's Wildcat No.2	Some large (approx. 20–25 m) *Vatica odorata* trees nearby.	19May10	40	Ferret badger	Northern Pig-tailed Macaque	Domestic Dog
KNpNR	300	18° 03′ 33″ N 105° 57′ 27″ E	Kishel's Weasel lure	Large number of rocky outcrops <1 m from man-made pathway.	19May10	40			
					TOTAL	**1,171**			

Notes: KGNR = Ke Go Nature Reserve, KNpNR = Khe Net proposed Nature Reserve / m asl = All elevations were recorded using a GPS and are therefore approximate microhabitat: microhabitat was not recorded during the 2006–2007 field surveys. All camera traps for the 2006–2007 survey were placed in secondary evergreen forest. All camera traps in the 2010 survey were placed along the hill range that lies between the two sites; habitat was predominantly lowland evergreen forest that undergone significant levels of human-induced disturbances, particularly selective logging. Trap days = the number of effective camera trap days, taken as the total number of 24-hour periods that the camera trap was operational for (*i.e.*, until the last clear photograph). If using multiple lures/baits, these were applied simultaneously at the camera trap station.

Table 3. Large mammal species confirmed to be present during surveys in the Ke Go – Khe Net Lowlands.

Common Name	Scientific Name	C. R. Robson 1990[1]	Le Trong Trai *et al.* 1999[2]	Le Trong Trai *et al.* 2001[3]	This survey
Northern Treeshrew	*Tupaia belangeri*		O	R	CT
Pygmy Loris	*Nycticebus pygmaeus*				O
Northern Pig-tailed Macaque	*Macaca leonina*		O	O	CT
Stump-tailed Macaque	*Macaca arctoides*		O	O	CT
Hatinh Langur	*Trachypithecus hatinhensis*			O	
Gibbon	*Nomascus*		H		
Yellow-throated Marten	*Martes flavigula*	O	O		CT, O
Stripe-backed Weasel	*Mustela strigidorsa*				CT
Yellow-bellied Weasel	*Mustela kathiah*	O			
Ferret badger	*Melogale* sp.		R[4]	O[4]	CT
Large-toothed Ferret Badger	*Melogale personata*				R
Asian Small-clawed Otter	*Aonyx cinereus*	O			
Common Palm Civet	*Paradoxurus hermaphroditus*				CT, O
Small-toothed Palm Civet	*Arctogalidia trivirgata*				O
Large Indian Civet	*Viverra zibetha*				O
Small Asian Mongoose	*Herpestes javanicus*		O	O	
Crab-eating Mongoose	*Herpestes urva*		O	O	
Leopard Cat	*Prionailurus bengalensis*		O		
Chevrotain	*Tragulus* sp.				CT
Sambar	*Cervus unicolor*		T	R	
Large-antlered Muntjac	*Muntiacus vuquangensis*		R	R	
Red Muntjac	*Muntiacus muntjak*		T	R	
Wild Pig	*Sus scrofa*		T	R	T
Black Giant Squirrel	*Ratufa bicolor*		O	O	CT, O
Cambodian Striped Squirrel	*Tamiops rodolphii*		O	O	O
Pallas's Squirrel	*Callosciurus erythraeus*		O	O	CT, O
Red-cheeked Squirrel	*Dremomys rufigenis*		O	O	CT
Hoary Bamboo Rat	*Rhizomys pruinosus*		O	O	
East Asian Porcupine	*Hystrix brachyura*		R	R	CT
Asian Brush-tailed Porcupine	*Atherurus macrourus*		O	R	CT

Notes: O = Directly observed, CT = Camera trapped, R = Remains (equivalent to 'S' or 'specimen' as used in Le Trong Trai *et al.* 1999, 2001), T = Tracks or signs, H = Heard.
[1]Craig Robson, pers. comm. Observations during birding trips to Ke Go Nature Reserve in February 1990. Taken from Roberton (2007).
[2]Le Trong Trai *et al.* (1999) listed an observation of Swinhoe's Striped Squirrel *Tamiops swinhoei*. This record has been omitted from this table as it is in error; the species only occurs in the northern highlands of Vietnam.
[3]Le Trong Trai *et al.* (2001) listed a track record for Eurasian Otter *Lutra lutra*. This record has been omitted from this table. The landscape could support as many as four otter species; tracks/prints are not a reliable way to record an otter species.
Sources:
[4]A specimen and an observation of *Melogale personata* was recorded in Le Trong Trai *et al.* (1999) and Le Trong Trai *et al.* (2001), respectively. The species identity is impossible to confirm in the field without assessing the dentition, and as there were no notes supporting these identifications, both records are re-labelled here as unidentified *Melogale*.

Species accounts

Stripe-backed Weasel Mustela strigidorsa

In Ke Go NR in October 2006 a single animal was camera trapped, possibly during the early morning/late afternoon/night (the photograph was not time-stamped, but the flash was triggered and the photograph's background suggests that light-levels were low) in secondary evergreen forest at approximately 130 m asl (18° 06′ 01″ N, 105° 51′ 42″ E; Figure 1). The camera trap was located on a hill side, approximately 150 m from a small stream and 25 m from a human-made pathway. The camera trap site was baited with Hawbaker's weasel lure and beef sausage. There is no evidence in the photograph to suggest that the animal was attracted to these baits and lures.

Figure 1. Cropped camera trap photograph of Stripe-backed Weasel *Mustela strigidorsa*, Ke Go Nature Reserve, 2006 (Photo: SVW).

Yellow-throated Marten Martes flavigula

Yellow-throated Marten was recorded twice within the landscape. At 15h10 on 14 October 2006 at 18° 05´ 29´´ N, 106° 00´ 29´´ E, a duo was observed running across the main access road (largely unpaved though it was gravelled in parts), and a duo was camera trapped at 15h03 on 3 November 2006 at 18° 07´ 38´´ N, 105° 56´ 26´´ E. Both records were at approximately 100 m asl. Baits and lures used at the camera trap station included beef sausage, dried fish, shrimp, one duck egg and Hawbaker's weasel lure. Both records were within secondary evergreen forest and in Ke Go NR. This species has already been confirmed in the landscape through observations in 1990 (C. Robson, pers. comm. in Roberton 2007) and 1996 (Le Trong Trai *et al.* 1999) both in Ke Go NR, and in 2000 in Khe Net proposed NR (Le Trong Trai *et al.* 2001).

Ferret badger Melogale *sp.*

One ferret badger observed in captivity on 9 November 2006 in Kim Lich village, Kim Hoa commune, Tuyen Hoa district, Quang Binh province, had reportedly been snare-trapped near the village; presumably opportunistically as there is no known targeted trade/hunting of either ferret badger species in Vietnam. It was released back into the forest before its

dentition could be checked and the species confirmed. Both Small-toothed Ferret Badger *M. moschata* and Long-toothed Ferret Badger are predicted based on habitat and regional specimen records to be present within the landscape (Roberton 2007), and the syntopy of these two species has been proven much further south in the country (Abramov & Rozhnov 2014). The only known reliable visual ways to distinguish between Small-toothed Ferret Badger and Large-toothed Ferret Badger is by assessing the dentition or, for males, the baculum (*e.g.*, Schank *et al.* 2009, Abramov & Rozhnov 2014).

On 7 March 2010 a dead ferret badger was brought in by a domestic dog to Xuyen A Forest Protection Department [FPD] station, Thuan Hoa commune, Tuyen Hoa district, Quang Binh province. It was unclear whether the dog killed the ferret badger or had found it poisoned, as there was no obvious signs of physical injury. Photographs of the dentition were taken and confirmed the specimen to be Large-toothed Ferret Badger *M. personata* (Figure 2). The ferret badger was promptly gutted, cooked and eaten by an FPD ranger stationed at Xuyen A FPD Station. There were an additional six camera trap ferret badger records over the survey; this was the most common small carnivore taxon in the landscape.

Common Palm Civet Paradoxurus hermaphroditus

A Common Palm Civet seen on 9 November 2006 in captivity in the village of Kim Lu, Kim Hoa commune, Tuyen Hoa district, had been bought from a local hunter.

At 19h45 on 14 November 2006 at 100 m asl, a Common Palm Civet was observed approximately 5 m up an unidentified tree species in heavily disturbed lowland evergreen forest that had been selectively logged in the past. The animal appeared indifferent to the observers and was observed for approximately 5 minutes. Distance from the observers to the animal was not recorded. On 15 November 2006, a Common Palm Civet was seen in the same tree at 21h34. It could not be determined whether this was the same individual seen the previous evening.

A Common Palm Civet was camera trapped on 20 November 2006 in secondary evergreen forest with a high density of bamboo (08° 02´ 12´´N, 105° 55´ 14´´ E, 220 m asl). The camera-trap was located at the foot of a hill approximately 50 m from a small stream and was baited with Hawbaker's weasel lure, dried fish and beef sausage.

On the 12 June 2010 at 21h51 a Common Palm Civet was camera trapped at 235 m ASL. The animal was photographed in lightly disturbed lowland evergreen forest, near the top of Moc Buoi hill, Ke Go NR (18° 06´ 02´´ N, 105° 55´ 59´´ E), an area that was relatively inaccessible. The camera trap was placed within 2 m of a well-used animal trail where wild pig Sus and unidentified mammal faeces had been found. One *Syzygium* tree on this animal trail was in fruit at the time.

Figure 2. Photograph showing the dentition of a dead Large-toothed Ferret Badger *Melogale personata* brought in by a domestic dog to Xuyen A FPD Station, Khe Net Nature Reserve, 2010 (Photo: D. Willcox/SVW).

Large Indian Civet Viverra zibetha

On 25 October 2006 at 21h50 a single animal was observed in mixed plantation (mainly eucalyptus and some native tree species). The animal was observed standing in a small open patch near the edge of Ke Go Reservoir (18°13´ N, 105° 96´ E, 50 m asl), at a distance of less than 30 m by torch light from a boat.

Small-toothed Palm Civet Arctogalidia trivirgata

Three confirmed records, detailed in Willcox *et al.* (2012), were obtained in the 2010 survey, all during spotlighting and all from Ke Go NR.

Threats to small carnivores

The survey team encountered frequent evidence of illegal hunting in the landscape (*e.g.*, Figure 3). Approximately 1,200 ground-level cable-snare traps, drift fence (a minimum of 2 km in total length) for funnelling animals into the cable-snare traps, and 17 illegal logging/hunting camps were recorded in approximately 30 km² during the 2006, 2007 and 2010 surveys.

Humans were one of the most frequently observed and photographed mammal species in the landscape. Camera traps recorded eight people, seven of whom were carrying chainsaws/heavy machetes, and three domestic dogs. Three camera traps were stolen and one was deliberately burnt also indicating human presence. Additionally, there was a total

of 88 encounters with people during the survey in 2010; people encroaching illegally into the landscape were encountered on a regular, often daily, basis.

Figure 3. Snare traps in an illegal camp in Ke Go Nature Reserve, 2010 (Photo: D. Willcox/SVW).

Although legal logging by state companies ceased in 1997, the roads and tracks constructed for transport are now used by illegal loggers. During the survey, it was not uncommon to see large groups (20+) of people transporting sawn timber (*Vatica odorata*, *Madhuca pasquieri* and *Magnolia* sp. were provisionally identified) from Khe Net proposed NR along the main track. The illegal loggers showed no fear of Forest Protection Department [FPD] Rangers, transporting sawn timber from the forest directly past the front of FPD Ranger stations by bicycle or domestic buffalo, or floating it on bamboo-rafts down the Khe Net River. Most of the large (DBH exceeding 40 cm) trees have now disappeared from the landscape and there is no undisturbed forest remaining within it; large trees were nearly absent even on the tops of some of the relatively inaccessible hills. At least 130 Domestic Water Buffaloes *Bubalus bubalis* were recorded during the survey. The majority of these buffaloes were being used to transport illegally harvested timber out of the forest.

Discussion

This survey confirmed the presence of six small carnivore species in the Ke Go – Khe Net Lowlands. This is a poor return considering the relatively high level of small carnivore focused survey effort. The low number of confirmed records indicates a landscape where most small carnivore species are either locally extinct or depressed in population. Even relatively robust small carnivore species, such as Leopard Cat *Prionailurus bengalensis* and Crab-eating Mongoose *Herpestus urvus*, went undetected, despite being confirmed in earlier surveys (Le Trong Trai *et al.* 1999: Appendix 2). These two species are readily

camera trapped (*e.g.*, Than Zaw *et al.* 2008, Chutipong *et al.* 2014) and are unlikely to have been overlooked if at all common at time of camera trapping. There were some records for other mammal species considered to be relatively tolerant of wildlife hunting and other anthropogenic pressures: an unconfirmed record for Wild Pig *Sus scrofa* in 2010, and a camera trap record for a Chevrotain species *Tragulus* sp. in 2007. Red Junglefowl *Gallus gallus* was only recorded twice; a camera trap photograph in 2006 and a direct observation in 2010. The only other ground-dwelling bird species recorded was Red-collared Woodpecker *Picus rabieri*, recorded once on a camera trap in 2006.

Few surveys in the region publish quantified assessments of wildlife hunting or other threats to biodiversity, hindering any comparison between sites, but, the threats recorded in the Ke Go – Khe Net Lowlands are likely to be at levels sufficient to have caused population declines/local extinctions. The core area of this landscape, the hill range that forms a border between Ke Go NR and Khe Net proposed NR, was clearly being targeted by wildlife hunters and illegal loggers. This area had the highest density of snare traps as well as the largest number of illegal camps. Wildlife hunting, particularly with indiscriminate ground-level cable-snare traps, is surely the main cause for these population declines and likely extirpations of a range of animal taxa, including small carnivores.

The Stripe-backed Weasel record is at the southernmost extent of the species' known distribution and at the lower reaches of its known elevation range (Roberton 2007, Abramov *et al.* 2008). The persistence of Stripe-backed Weasel in secondary evergreen forest, in a landscape where most other similar sized or larger terrestrial animal species are either locally extinct or too low in number to be detected using a relatively high survey effort, may suggest that this rarely recorded species is probably not threatened by either habitat degradation or cable-snare traps. Stripe-backed Weasel is likely to be present in a wide range of both protected areas and non-protected forested areas within its range. Most conventional survey methodologies (including camera trapping) are unsuitable for weasels and it, along with several other weasel species in the region, is probably going undetected and is unlikely to be genuinely absent if suitable habitat is present (*e.g.*, Streicher *et al.* 2010, and weasel records traced in Chutipong *et al.* 2014).

Small-toothed Palm Civet is a highly arboreal, nocturnal species of small carnivore; it is very rarely recorded during general faunal/mammal surveys except if using spotlighting. The relatively large number of records from this site, as well those from other similarly faunally depauperate and degraded habitats in Vietnam, suggest that it is relatively tolerant of habitat degradation as well as wildlife hunting (particularly ground-level trapping), and is very unlikely to be currently threatened within its range (see Willcox *et al.* 2012).

The four remaining small carnivore species recorded are all typical of degraded, faunally impoverished habitats, where wildlife hunting has caused the extirpation of most

other terrestrial animal species (*e.g.*, Pei *et al.* 2010, Streicher & Ulibarri 2014). Common Palm Civet, Yellow-throated Marten and ferret badger have all been recorded in a relatively large number of such habitats in Vietnam (Willcox *et al.* 2014: Table SOM3). Of the four, Large Indian Civet is likely to be more vulnerable to cable-snare trapping; it is ground-dwelling, of a relatively large size, and is likely to be a target for the illegal wildlife trade, of which civet meat forms a significant proportion in Vietnam and China (*e.g.*, Bell *et al.* 2004, Roberton 2007). Though Large Indian Civet was only recorded once during this survey in 2006, its presence in a landscape where most similar sized animals were either locally extirpated or at low and therefore undetectable densities, suggests that this species may be relatively tolerant of intensive hunting pressures, compared to some of the target small carnivores not recorded during these surveys, including Binturong and Owston's Civet.

Conclusions

The Ke Go – Khe Net Lowlands first received international attention through the rediscovery of 'Vietnamese Pheasant' (now Edwards' Pheasant) in the 1990s. This led to half of the landscape being decreed a protected area in 1996. Together with Khe Net proposed NR, this landscape was considered one of the largest contiguous blocks of Annamese lowland evergreen forest remaining in Vietnam, and therefore of global importance to biodiversity conservation.

The survey results in this report evince a landscape where a wide range of animal taxa, including small carnivores, are either locally extinct, or have gone through significant population declines. This includes several animal species considered to be global conservation priorities, including Owston's Civet and Edwards' Pheasant. Camera trapping was undertaken in areas where the latter species had been recorded previously (see Eames *et al.* 1994) and although the civet has no certain record, based on habitat type it is likely to have been present. The main cause in these population declines is wildlife hunting, which has been exacerbated by decades of mismanagement by the Vietnamese authorities mandated to conserve this landscape, and a failure by these authorities to patrol and remove cable-snare traps. This situation is far from unique to the Ke Go – Khe Net Lowlands and similar patterns of negligence and hunting-driven declines have been observed in other protected areas in Vietnam, even those that are relatively well funded and otherwise resourced (*e.g.*, Cat Tien NP: Brook *et al.* 2014).

It is highly unlikely that the Ke Go – Khe Net Lowlands retains globally significant populations of any priority species of bird or large mammal. Better management of the landscape, which should include snare-trap removal and the suppression of illegal logging activities, would help some wildlife populations to recover, and establish the landscape as a potential reintroduction site for priority species. However, the priority conservation action for the Annamese Lowlands and their faunal and floral communities, including the

threatened endemic species, must now be to secure sites that have not yet acquired the Ke Go – Khe Net Lowland's faunally impoverished status, and for which there is a possibility of successfully conserving a range of Annamese endemics and lowland species in-situ. Forested areas along the Quang Binh – Quang Tri border are probably the priority sites, particularly Khe Nuoc Trong, where several globally threatened mammal and bird species have been recorded, including some Annamese endemics (CEPF 2011, Viet Nature Conservation Centre unpublished data).

Acknowledgements

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ORIGINAL ARTICLE

Recent records of Large-spotted Civet *Viverra megaspila* from Peninsular Malaysia

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Abstract.

To date there have been few published records of Large-spotted Civet *Viverra megaspila* across much of its range. It is one of the least known small carnivore species in Peninsular Malaysia, where there have been no published records of this species since 1985. Here we present new photographic evidence of Large-spotted Civet in Peninsular Malaysia from a camera-trap study and a road-killed animal. This represents a significant finding of this species after a lapse of more than 25 years. Our findings also support the suggestion that this species is likely tolerant or has adapted to human disturbance and habitat modification, since both records were found in and around palm oil plantations bordering evergreen forest. However, to what extent it uses palm oil plantations is unknown and further studies are needed to determine this.

Keywords: camera-trapping, forest fringe, oil palm, road-kill, small carnivore

Introduction

Large-spotted Civet *Viverra megaspila* is listed as Vulnerable on *The IUCN Red List of Threatened Species* (Duckworth *et al.* 2008). It is distributed across mainland South-east Asia, with records from Myanmar, Thailand, Vietnam, Lao PDR (Laos), and Peninsular Malaysia (Schreiber *et al.* 1989, Duckworth 1994, Roberton 2007, Chutipong *et al.* 2014), Cambodia (Gray *et al.* 2010), as well as South China (Francis 2008, Lau *et al.* 2010). Despite its wide distribution across South-east Asia, there is a lack of information regarding the species' conservation status and country-specific distribution patterns in parts of its range (Jenks *et al.* 2010). Since the late 1990s, Cambodia, Thailand, Myanmar, Vietnam and Lao PDR have all confirmed the presence of Large-spotted Civet via camera-trapping

surveys (Austin 1999, Nguyen *et al.* 2004, Lynam *et al.* 2005, Gray *et al.* 2010, Jenks *et al.* 2010, Chutipong *et al.* 2014, Gray *et al.* 2014). The species is distributed in lowland habitats and it is threatened by forest conversion as well as wildlife hunting (Duckworth *et al.* 2008). It is considered one of the regional priorities for small carnivore conservation and the species is in decline across its range (Roberton 2007, Than Zaw *et al.* 2008, Chutipong *et al.* 2014, Gray *et al.* 2014)

Large-spotted Civet is one of eleven Viverridae (civets) species that can be found in Peninsular Malaysia, and has been classified as Endangered on a national level under the Red List of Mammals for Peninsular Malaysia (DWNP 2010). There have been four known published confirmed records of this species from the country, in addition to one known museum specimen of an unconfirmed origin. Three of these published records originate from north-west Peninsular Malaysia (Robinson & Kloss 1920, Asakawa *et al.* 1986, Gaubert 2003), whilst another record was obtained from Kuala Lumpur which is located in the central-west portion of the Peninsula (Robinson & Kloss 1920). The last published Malaysian record of the species was that of a road-kill found in Sungai Petani in 1985, Kedah state (Asakawa *et al.* 1986). There is one museum specimen exhibited at the Perak Museum in Taiping, Perak state; however, the details and origin of the specimen are unknown.

Here, we provide two new locality records for the species in Peninsular Malaysia, one from a rapid camera-trap survey in and around a palm oil estate in Kedah state, and another from an incidental road-kill detection in Perak state.

Materials and methods

Study site

A rapid camera-trap survey was conducted within the Sungai Dingin Palm Oil Estate (Sungai Dingin Estate) and Gunung Inas Forest Reserve which are both located in Kedah state, north-west Peninsular Malaysia (Figure 1). Sungai Dingin Estate encompasses an area of about 32 km², and does not exceed 200 m asl. During the survey, most of this plantation comprised mature palm oil trees, while some sections were newly replanted or recently cleared for replanting. To the east, Sungai Dingin Estate shares a border of approximately 20 km with Gunung Inas Forest Reserve (362 km²; Ross 2010), where a ridge from this forest reserve extends westward through the palm oil estate. Gunung Inas Forest Reserve is dominated by evergreen forest and is part of the Bintang Hijau Mountain Range. It is classified as a production forest, and timber extraction is permitted, though there was no active logging within the study site at the time of the survey.
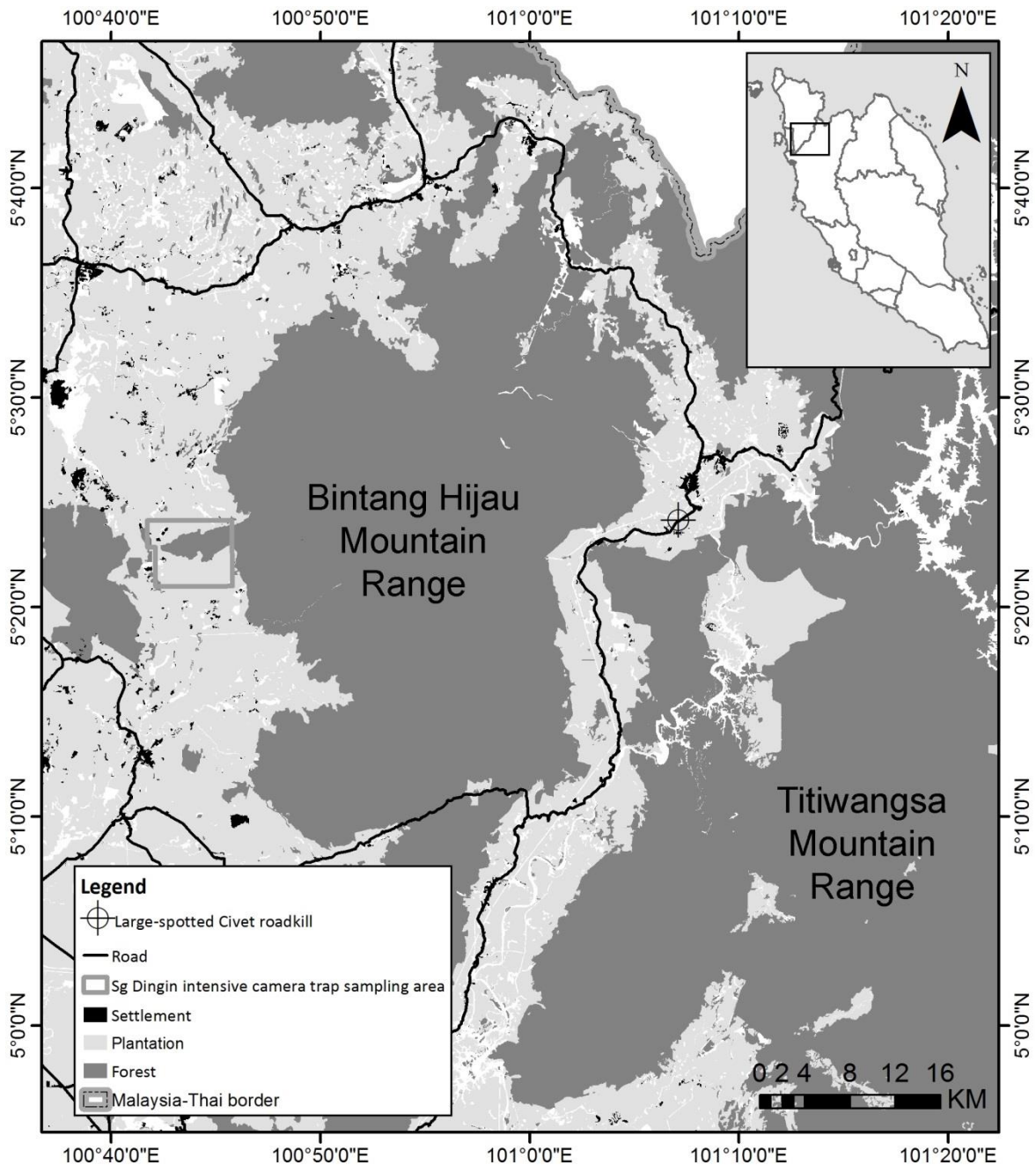
Figure 1. Camera-trapping site in Sungai Dingin, Kedah (August to November 2011) and road-kill location in Gerik, Perak (November 2014).

Methods

A rapid biodiversity assessment was conducted within the Sungai Dingin Palm Oil Estate, using a combination of sign surveys and camera-traps. The sign surveys were primarily used to determine the occurrence of large mammal species within the study site and not for confirming the presence of Large-spotted Civet or other small carnivore species, for which sign-based records, unless supported by DNA analysis, are unreliable (*e.g.*, Davison *et al.* 2002). An area of 57 km² was sampled across three pre-defined habitat zones: palm oil

plantation (27 km²), evergreen forest (20 km²) and forest edge (10 km²). A total of 57 camera-traps were set, with an average inter-trap distance of 670 m between locations The camera-traps were set to be operational for 24 hours a day throughout the sampling period of three months (August to November 2011), and were set at elevations ranging from 30–640 m asl. All of the camera-traps were set within a period of several days, and the stations were maintained throughout the entire study period. Of the 57 camera-traps locations, 27 were located inside the plantation, 10 were at the forest edge and 20 were set within the forest reserve. Camera-traps were mounted to trees at an approximate height of 40–50 cm above ground, facing locations suitable to photograph mammals such as plantation trails, ridges, old logging roads, and other trails which had evidence of animal usage. Commercially-made camera-traps, Reconyx Hyperfire (HC500), were used in all surveys.

Results

From a total of 5,090 camera-trap nights, Large-spotted Civets were recorded at two different camera-trap stations within the palm oil estate (Table 1), which had a total sampling effort of 2,527 camera-trap nights. These two camera-trap stations were less than 1 km away from the border of Gunung Inas Forest Reserve.

Table 1. Large-spotted Civet *Viverra megaspila* records from the camera-trapping site in Sungai Dingin, Kedah state (August – November 2011) and the road-kill record near Gerik town, Perak state (November 2014).

Coordinates (DD MM SS)	Elevation (m asl)	Date	Time	Notes
5° 22′ 06″ N 100° 42′ 42″ E	77	24Sep2011	01h59	A male was camera-trapped once at this location within a palm oil plantation less than 1 km away from forest edge.
5° 23′ 30″ N 100° 42′ 42″ E	72	07Sep2011 19Sep2011 22Sep2011 25Sep2011 29Sep2011 20Nov2011	03h16 06h02 01h22 05h10 04h05 23h56	A female was camera-trapped six independent times at this location within a palm oil plantation, less than 1 km away from the forest edge.
5° 24′ 54″ N 101° 07′ 42″ E	120	15Nov2014	23h59	A fresh road-kill of a female was found by a roadside surrounded by palm oil plantations and settlements.

Based on their unique spot patterns, which were manually identified by experienced field researchers, two individuals were identified. A male, sexed based on the presence of external genitalia visible in some of the camera-trap photographs, was recorded once at an elevation of 77 m asl (Figure 2). A female, sexed on the absence of any external genitalia, was photographed during six independent events at a separate camera-trap location, at an elevation of 72 m asl. The distance between these two camera trap stations was approximately 2.5 km, and all of the photographs were taken from around 24h00 to 06h00. Independent events are defined here as consecutive camera-trap photographs of an individual of the same species taken more than 30 minutes apart (see O'Brien *et al.* 2003).

As for the sign surveys, only very few small carnivore tracks were found during the sign surveys.

Figure 2. The male Large-spotted Civet captured on camera-trap (Photo: WWF-Malaysia/Ching Fong Lau).

A female Large-spotted Civet road-kill (Fig. 3) was found on 24 November 2014, along a 5–6 m wide paved road near Gerik town, Perak state. The road-kill was in an area that was surrounded by palm oil plantations and less than 50 m from human settlements. The closest and largest forest blocks (greater than 100 km^2) from the road-kill locality are approximately 3 km to the east (Air Cepam Forest Reserve within the Titiwangsa Mountain Range) and about 4.5 km to the west (Bintang Hijau Forest Reserve within the Bintang Hijau Mountain Range). At the time of discovery at approximately midnight, the carcass was still fresh. The Large-spotted Civet carcass was not collected.

Discussion

Prior to our findings, there have been four known published records of Large-spotted Civet with locality details in Peninsular Malaysia; from Kuala Lumpur and Taiping (Robinson & Kloss 1920); Sungai Petani (Asakawa *et al.* 1986); and Penang (Gaubert 2003). Because of insufficient documentation, it is unknown whether the specimen in the Perak State Museum originates from any of the published records. The records detailed in this paper are the first confirmed published records of this globally-threatened small carnivore species in Peninsular Malaysia since 1985.

Figure 3. The female Large-spotted Civet road-kill (Photo: WWF-Malaysia/Christopher Wong).

Intensive camera-trap surveys conducted in the Belum–Temengor Forest Complex in the north-central region (Rayan *et al.* 2013; 40,161 trap nights), and Taman Negara National Park in the central region (Kawanishi & Sunquist 2004; 14,054 trap nights) of Peninsular Malaysia failed to detect Large-spotted Civet. It was also not recorded in other camera-trap studies spanning across multiple sites within Peninsular Malaysia (Mohd Azlan 2003, Lynam *et al.* 2005, Hedges *et al.* 2013). However, it should be noted here that most of these large-scale camera-trap surveys were focused on large mammals, and were conducted in national parks, state parks and forest reserves. Little camera-trapping survey effort has been invested in areas of habitat that have undergone human-induced disturbance, such as the edges of natural forest and palm oil plantations. We hypothesise that this could be one reason why this species has not been detected, despite the relatively large number of intensive camera-trap surveys in Peninsular Malaysia.

Our findings corroborate a recent publication stating that this species' Malaysian distribution is less extensive than described in Medway (1969), Corbet & Hill (1992) and Francis (2008), and is likely to be confined to north-west Peninsular Malaysia (Jennings & Veron 2011), which could be the southernmost limit of its global distribution. However, the outlier recorded from Kuala Lumpur (Robinson & Kloss 1920) is unable to be explained or verified. Historically, Kuala Lumpur was the centre of Malaysia's administration and commerce, hence plausible explanations on the origins of the outlier is that this specimen was obtained via trade, or has been misidentified; Large-spotted Civet has similarities to

Malay Civet *Viverra tangalunga* and Large Indian Civet *Viverra zibetha*, and both of these latter species are distributed in Peninsular Malaysia (IUCN 2015). For example, one specimen claimed to be Large-spotted Civet, from Singapore, in the Muséum National d'Histoire in Paris was a Malay Civet (Chua *et al.* 2012).

Large-spotted Civet is thought to be a lowland species, with most of the field records obtained from areas below 300 m asl (Duckworth 1994, Jennings & Veron 2011, Chutipong *et al.* 2014, Gray *et al.* 2014). Our results are consistent with this, and all records were below 150 m asl. Large-spotted Civet is reported to be relatively tolerant of forest degradation and may be closely associated with forest edge habitats (*e.g.*, Duckworth 1994, Austin 1999, Jenks *et al.* 2010, Chutipong *et al.* 2014), and it has also been recorded from an extensive logged-over area (Lynam *et al.* 2005). Although previous records have been obtained from evergreen forest, semi-evergreen forest, Melaleuca dominated swamp forest and deciduous dipterocarp forest (*i.e.*, dry dipterocarp forest; Duckworth 1994, Austin 1999, Nguyen *et al.* 2004, Khounbouline 2005, Lynam *et al.* 2005, Gray *et al.* 2010, Jennings & Veron 2011, Chutipong *et al.* 2014), its precise habitat requirements and ecology remain poorly known (Austin 1999).

To our knowledge Large-spotted Civet has not been recorded in palm oil plantations or similar agricultural land, and the camera-trap records in this paper are the first published examples of this. The road-kill is likely to have originated from either the Titiwangsa Mountain Range or the Bintang Hijau Mountain Range; the latter is where the camera-trap records were obtained. The localities of these records suggest that the species is closely associated with forest edges or lowland forested areas that have been converted to plantations, and is likely to be using plantations as feeding grounds or movement corridors. More studies are needed to confirm this.

Our records of Large-spotted Civet have given some insights on its current conservation status and distribution in Peninsular Malaysia. Our findings indicate that lowland forests bordering plantations could be important habitats for the Large-spotted Civet; these habitats and potential refuge sites should not be haphazardly converted to palm oil plantations or to other similar land uses. Wildlife hunting is also likely to be more prevalent in lowland forest areas close to human settlements; hence these potential threats to the species should be addressed by the relevant enforcement agencies. Nevertheless, further detailed studies on its ecology and distribution in Peninsular Malaysia are needed so that further conservation actions can be devised and applied to ensure the survival of this species in the country.

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Confirmation of the presence of Crab-eating Raccoon *Procyon cancrivorus* (Procyonidae) in the Colombian Amazon, hypothesis of distributional area, and comments on juvenile specimens

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Abstract.
In Colombia, the Crab-eating raccoon *Procyon cancrivorus* is distributed in the Andes, Caribe, Chocó, and the Orinoco regions, from sea level up to 2500 m. Although its presence in the Amazon region is probable, based on records of adjacent countries such as Ecuador, to date, there are not verified records from this region in Colombia. In this work we report a juvenile male specimen from Villa Garzón, Department of Putumayo, Colombia. This record corroborates the presence of the taxon in the Colombian Amazon. Considering previous distributional maps in Ecuador and Colombia, our data increased the range of this species to zones in the Magdalena Valley and Amazon regions of Colombia, Andes mountains and Pacific of Ecuador and Colombia. Based on additional juvenile specimens deposited at Colombian collections, we describe some external and cranial characters.

Keywords: Crab-eating raccoon, conservation, distributional records, new locality, range increase.

Confirmación de la presencia de *Procyon cancrivorus* (Procyonidae) en la región de la Amazonía colombiana, nueva hipótesis de área de distribución y comentarios sobre individuos juveniles

Resumen.
En Colombia, el Mapache cangrejero *Procyon cancrivorus* se distribuye en los Andes, el Caribe, el Chocó, y la región de la Orinoquía en un rango altitudinal comprendido entre los 0 y 2500 m. Aunque la presencia de la especie en la Amazonía de Colombia es probable, con base en registros de localidades de países vecinos como Ecuador, hasta el momento se desconocen de registros verificados provenientes de esta región. En el presente trabajo registramos un ejemplar juvenil macho proveniente de Villa Garzón, departamento del Putumayo, Colombia. Con este registro corroboramos la distribución geográfica de este taxón en la Amazonía colombiana. Considerando el área de distribución propuesta previamente para la especie en Ecuador y Colombia, la nueva área de distribución se incrementó a zonas en los Andes y Pacífico de Colombia y Ecuador, y el Valle del Magdalena y Amazonía Colombiana. A partir de ejemplares juveniles adicionales depositados en colecciones colombianas, describimos algunos caracteres externos y craneales.

Palabras clave: conservación, incremento del rango, mapache cangrejero, nueva localidad, registros de distribución

The genus *Procyon* comprises three species: the Cozumel Raccoon *Procyon pygmaeus*, endemic to Cozumel Island; the Northern Raccoon *Procyon lotor*, and the Crab-eating Raccoon *P. cancrivorus* (Helgen & Wilson 2005). In South America, two species have been reported: *P. lotor*, distributed in the Caribbean region of Colombia and probably Venezuela (Helgen & Wilson 2005, Marín *et al.* 2012, Helgen *et al.* 2013), and *P. cancrivorus*, which extends in South and Central America from Panama to Northern Argentina (13,254,551 km², Reid & Helgen 2008).

The distribution of Crab-eating Raccoon *P. cancrivorus* in Colombia and Ecuador have been recently updated, including available records from different regions of these countries, on an elevational range from sea level to 2,350 m asl (Marín *et al.* 2012). In these countries, the species is widely distributed; however no records from the Amazon region of Colombia are available (Marín *et al.* 2012), but its presence in this region was suggested by Reid & Helgen (2008). In this communication, we introduce verified records of *P. cancrivorus* from one locality of the Colombia Amazon, corroborating the presence of the species in this area. In addition, we updated the distribution map for the species in South America, based on the inclusion of recent records from Colombia and Ecuador available in literature.

Confirmed record from the Colombian Amazon

Two young male individuals from a litter were rescued on December 2011, after the mother was killed by a domestic dog, in Villa Garzón, Department of Putumayo, near to Caucayá river (0º 3′ N, 75º 2′ W, 212 m asl), in the Colombian Amazon. Both animals were taken to the Centro Experimental Amazonico in Mocoa, Putumayo, to provide them food and care. Both individuals survived for 95 days. Only the skin of one of them was preserved and deposited at the Biological Collection of the University of Nariño (MUN). The specimen (MUN 0635) was preserved as skin and presents the following external measurements: total length 404 mm, tail 104 mm, foot 58 mm, and ear 28 mm. We reviewed one skin of a young male of *P. cancrivorus* (Figure 1).

Hypothesis of distributional area

We compiled a database with 45 geo-referenced records of *P. cancrivorus* from Colombia and Ecuador. The database included the records provided by Marín *et al.* (2012), the new record of this study (Figure 1), and others as indicated in the Table 1.

In this study, we use the species distribution modelling program MAXENT (ver. 3.3.3e; Phillips *et al.* 2006) to predict the distribution of *P. cancrivorus*. MAXENT integrates environmental data with species locality information to give a relative measure of suitability across a study area (Phillips *et al.* 2006). Because models using only presence data can be affected by spatial autocorrelation, we applied a spatially filtering locality analysis considering the climate heterogeneity (Veloz 2009, Boria *et al.* 2014). We used 39 localities from the 45 localities to the construction of the model.

For environmental data, we used a set of eight uncorrelated (Pearson's correlation coefficient $r > 0.7$) bioclimatic variables, some of which could reasonably be assumed to affect species ecology: Annual mean temperature, mean diurnal range, temperature seasonality, mean temperature of coldest quarter, annual precipitation, precipitation of wettest month, precipitation of driest month and precipitation of warmest quarter. Climate variables were obtained from the WorldClim database (www.worldclim.org ver. 1.4,

Hijmans *et al.* 2005) at a resolution of 1 km^2. All environmental data were standardized to geographic coordinates (Datum WGS-1984). We developed 25 replicate models for *P. cancrivorus* based on bootstrapped subsamples of available occurrence data, 25% of random test points and maximum background 60,000.

Table 1. Records of *P. cancrivorus* from Colombia and Ecuador used for the new map of distribution. The marks (*) indicate the excluded records.

Dept./Prov.	Rec.	Locality	Latitude	Longitude	Source
Antioquia	1	Puerto Berrío	6°29′ N	75°24′ W	1
	2	Medellín, Corregimiento de Santa Elena, vereda Chorroclarín, 2,350 m asl	6°13′ N	75°29′ W	1
	3	Frontino	6°47′ N	76°7′ W	1
	4	Puri, above Caceres	7°49′ N	75°12′ W	2
	5	Valdivia	7°16′ N	75°24′ W	2
Bolívar	6	San Juan Nepomuceno	9°54′ N	75°6′ W	2
	7	Cartagena	10°31′ N	75°30′ W	1
Caldas	8	Victoria, vereda El Llano, Finca Sabanilla, 312 m asl	5°19′ N	74°54′ W	1
	9	Norcasia	5°34′ N	74°53′ W	1
	10	Manizales, Corregimiento el Manantial, Vereda Espartillal, 1,950 m asl	5°7′ N	75°28′ W	1
Cauca	11	Río Saija, La Boca	2°43′ N	77°28′ W	1
Casanare	12	Orocué	5°8′ N	71°30′ W	1
Cesar	13	La Jagua de Ibirico, Corregimiento de la Victoría de San Isidro, Veredas Alto de las Flores and the Zumbador.	9°32′ N	73°19′ W	3
Chocó	14	Riosucio, PNN Katíos, right margin of Peye River, Peye zone.	7°48′ N	77°8′ W	1
	15	Río Sucio, PNN Katios, vereda Sautata, left margin of Atrato River, 100 m of the cabin.	7°48′ N	77°8′ W	1
	16	Ungia	8°7′ N	77°5′ W	2
Córdoba	17	Socorro, upper Río Sinú	8°35′ N	75°54′ W	2
Cundinamarca	18	Bogotá	4°36′ N	74°4′ W	1
	19	El Triunfo, near to Viotá	4°30′ N	74°28′ W	1
La Guajira	20	La Guajira	11°21′ N	72°31′ W	Footprints
Huila	21	Villavieja	3°12′ N	75°14′ W	1
Magdalena	22	PNN Isla de Salamanca	10°59′ N	74°31′ W	1
	23	Cerro de San Lorenzo, Sierra Nevada de Santa Marta, 1900 m	11°4′ N	73°59′ W	1
	24	*PNN Isla de Salamanca, Km 5 carretera Barranquilla-Ciénaga	10°59′ N	74°42′ W	1
	25	*PNN Isla de Salamanca, Km 16-17 carretera Barranquilla-Ciénaga	10°59′ N	74°35′ W	1
	26	PNN Isla de Salamanca, Los Cocos	10°59′ N	74°31′ W	1
	27	Santa Marta	11°14′ N	74°6′ W	1
	28	*Pueblo Viejo, Vía Parque Isla de Salamanca	10°58′ N	74°30′ W	4
	29	Pueblo Viejo, Santuario de Fauna y Flora de la Ciénaga Grande	10°50′ N	74°24′ W	4
Nariño	30	Tumaco, Santa María	1°40′ N	78°39′ W	1
Santander	31	Bucaramanga, vereda Vijagual	7°11′ N	73°3′ W	Photographs
Sucre	32	Tolú, Caño Francés	9°32′ N	75°34′ W	1
	33	Coloso, Las Campanas	9°32′ N	75°22′ W	2
Tolima	34	Ibagué, km 10, road from Ibagué to Bogotá	4°23′ N	75°10′ W	1
Putumayo	35	Puerto Garzón, near to Caucayá river, Department of Valle del Cauca	0°4′ N	75°2′ W	New record
	36	Buenaventura, San Miguel, Río Naya	3°26′ N	76°35′ W	1
Manabí	37	Manabí, between Bahía de Caraquez and Pedernales	0°35′ S	80°21′ W	
Morona Santiago	38	Arapaicos, near to Macas	0°14′ S	78°31′ W	
Napo	39	El Reventador	0°5′ S	77°39′ W	
	40	Avila Viejo	0°36′ S	77°30′ W	
Orellana	41	Loreto, San José de Payamino, 300 m asl	0°30′ S	77°16′ W	1
	42	Loreto, Cotapino river, Alto Napo	0°33′ S	77°47′ W	
	43	El Cristal, near to Auca	4°7′ S	79°12′ W	
Oro	44	Arenillas, Reserva Militar Arenillas	3°28′ S	80°13′ W	
	45	*Arenillas, Destacamento Cayancas, estero Viernes Santo 'Las Tomateras'	3°28′ S	80°9′ W	

(COLOMBIA — records 1–36; ECUADOR — records 37–45)

Sources: 1: Marín *et al.* 2012, 2: SiB Col 2014, 3: Ramírez 2009, 4: Moreno-Bejarano & Álvarez-León 2003; SiB Col = *Sistema de información sobre Biodiversidad de Colombia.*

We measured the accuracy of the MAXENT models using the Area Under the Curve (AUC) of the Receiver Operating Characteristic (ROC) curve, which is a threshold-independent measure of a model's ability to discriminate between absences and presences (Fielding & Bell 1997). Models with AUC > 0.75 for both training and test data were accepted, but the average model was retained for the analysis. Logistic model selected was transformed to boolean layers (*i.e.*, presence-absence) with a cut-off threshold equal to the minimum training presence (Pearson *et al.* 2007), which sets the threshold at the lowest
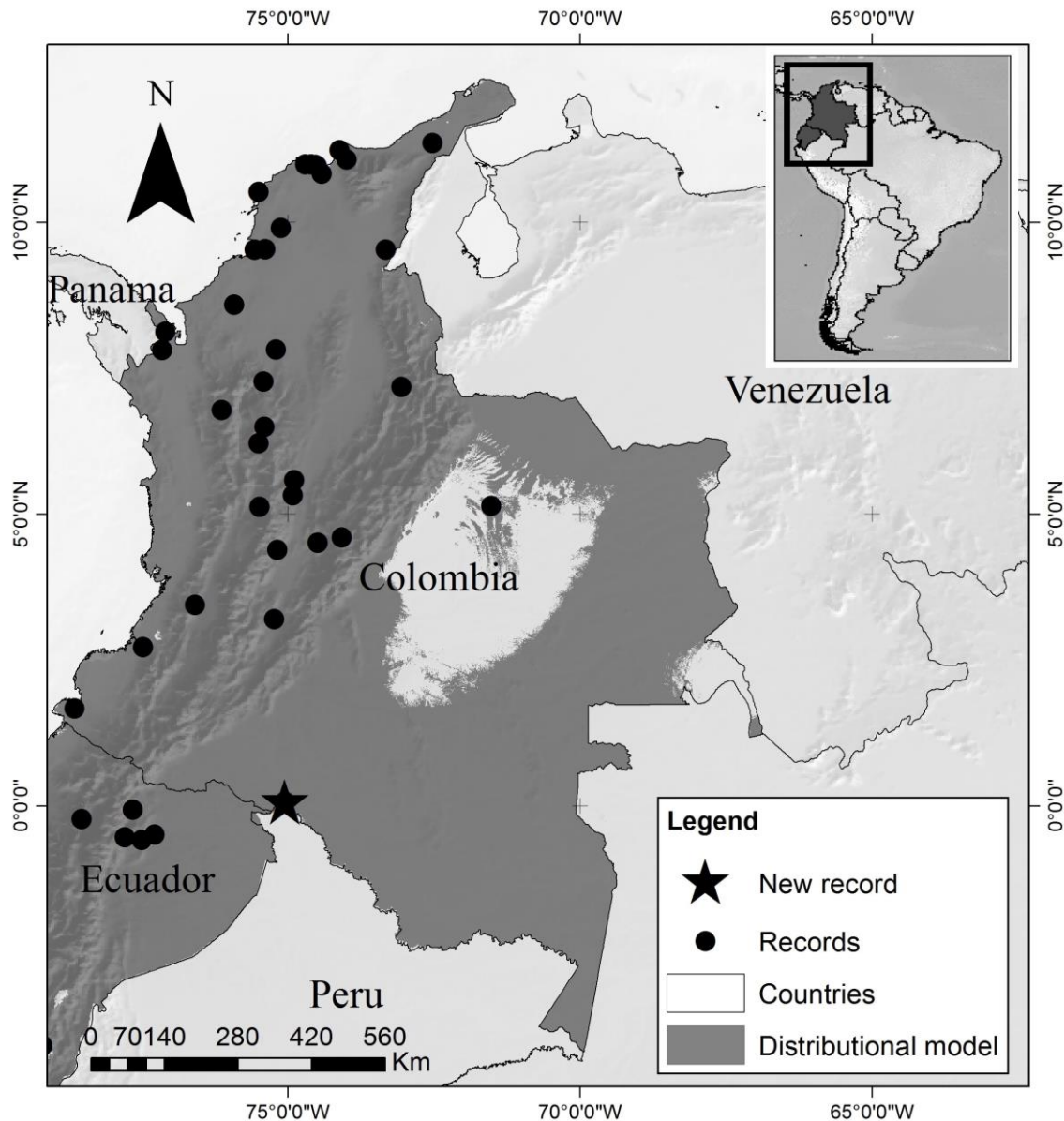
Figure 1. Specimen of Crab-eating Raccoon *Procyon cancrivorus* from Villa Garzón, Putumayo (Colombia).

Of the 45 localities, 36 were presence records from Colombia and nine localities from Ecuador (Figure 2). The distributional model (training AUC = 0.9, test AUC = 0.8; cut-off threshold = 0.1) of *P. cancrivorus* predicted an area of 1,480,685 km^2 for Colombia and Ecuador (Figure 2). In comparison with the previous distribution map (see Reid & Helgen 2008), the new one increased the area of distribution in 469,810 km^2 (32%; Figure 3). Here the distributional area of *P. cancrivorus* was extended to zones in the Magdalena Valley and Amazon regions of Colombia, Andean mountains and Pacific of Ecuador and Colombia (Figure 2). The model predicted low suitable habitat in Colombian Llanos of the Orinoco region.

The presence of Crab-eating raccoon in Colombian Amazon was inferred by Marín *et al.* (2012) based on records from Ecuador; the new record presented here (Figure 1) corroborates this assumption. The new locality (Villa Garzón) is characterized by the presence of tropical wet forest and other habitats near of rivers and streams; these habitats have been suggested as suitable for the species (Emmons & Feer 1999, Tirira 2007, Arispe *et al.* 2008).

A recent distributional map of *P. cancrivorus* excluded part of the Andes and Chocó regions in Colombia and Ecuador (Reid & Helgen 2008), from which there is available extensive evidence of its presence (see Marín *et al.* 2012). The records and the distributional model indicate that *P. cancrivorus* has a wide distributional area, that probably may be associated with the generalist habits and high tolerance to human-disturbed environments. In these areas *P. cancrivorus* can use garbage and exotic species as food resources (Gatti *et al.* 2006). This pattern has been also observed in *P. lotor* for which its movements and spatial distribution are affected for anthropogenic food resources

(Prange *et al.* 2004). Probably the distribution of *P. cancrivorus* is affected by the human settlements (*e.g.*, towns, cities), but ecological analyses are necessary to test whether urban ecosystems may represent a new available habitat for the species' range expansion or contraction. The new map of distribution of *P. cancrivorus* is a large scale hypothesis which could be employed to regional analysis, but local analysis needs of more accuracy.

Figure 2. Records of Crab-eating Raccoon *Procyon cancrivorus* in Colombia-Ecuador modified from Marín *et al.* 2012 (black circles). The locality of the new record from Amazonas region of Colombia (black star) and its potential distribution obtained with MAXENT.
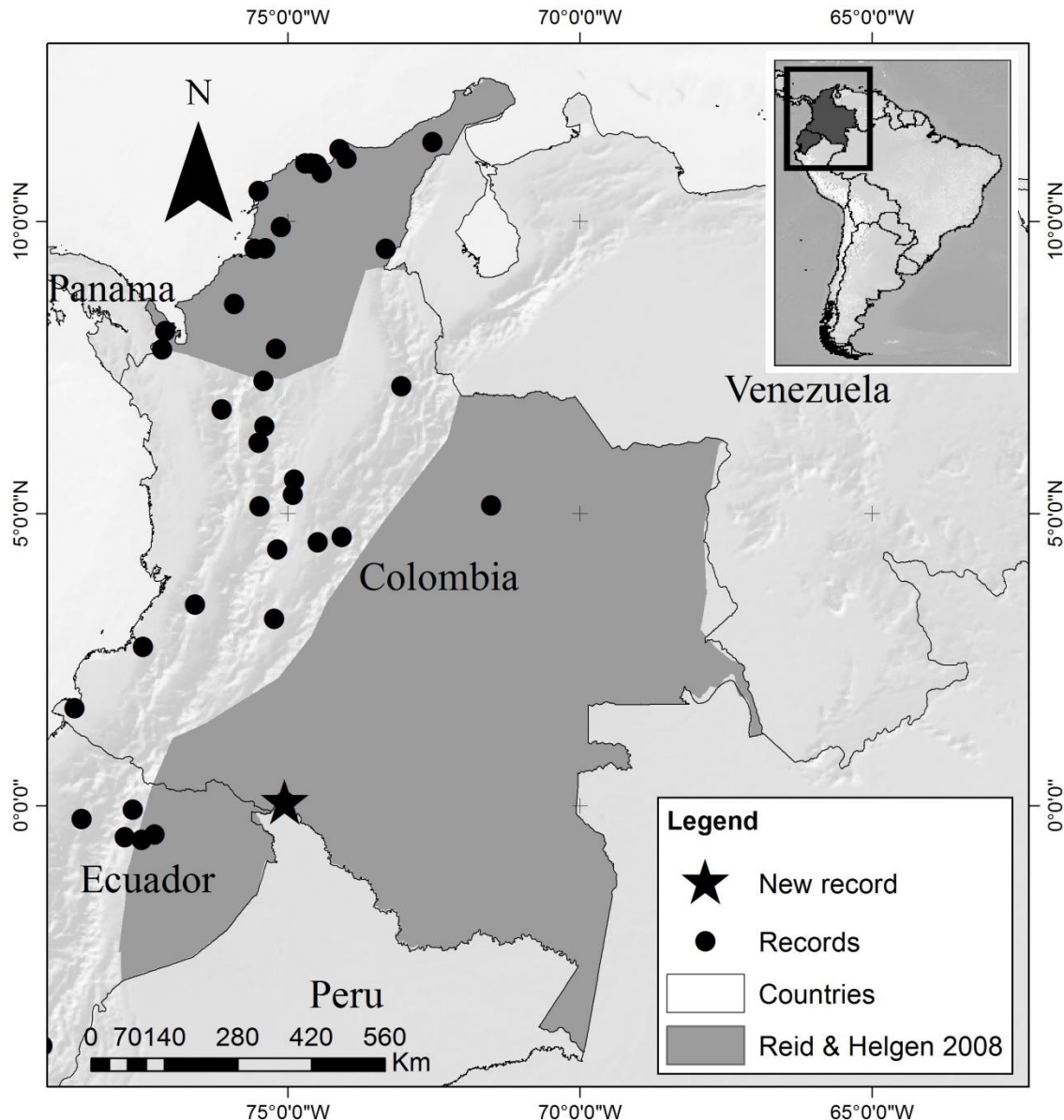
Figure 3. Updated distribution of the Crab-eating raccoon in Colombia and Ecuador. Shaded area shows the distribution suggested by Reid & Helgen (2008) in these countries.

The model of potential habitat indicates that in the Andean highlands there are favourable environmental conditions for the colonization of *P. cancrivorus*, however, the records from elevations over 2,350 m were absent. More information is necessary about the habitat requirements and behaviour of the *P. cancrivorus* in the Andean mid and high-lands.

Comments on juvenile specimens from Colombia

Due the scarcity of information regarding to juvenile specimens from Colombia, external characters of both juvenile individuals from the Amazon region of Colombia are described

herein. At the time of rescue (Figure 1) both individuals exhibited mixed short brown and long white hairs (mantle); the head was white with a small black mask around the eyes, ears relatively short and whitish. Blackish dorsum, interspersed with gray, and grayish ventral region. After 95 days, changes in the coloration were observed: Head and ears became blackish with cinnamon hairs, and the black mask around the eyes became broader but still ambiguous in the nose, in comparison with adult specimens. The dorsum became darker, with dark brown and yellowish hairs; the ventral region orange. The tail exhibited black rings poorly defined in both stages.

We found six juvenile specimens deposited at the Instituto Alexander von Humboldt (IAvH), Villa de Leyva, and Instituto de Ciencias Naturales, Universidad Nacional de Colombia (ICN), Bogotá. Two females (IAvH 345, IAvH 346) were collected at Department of Magdalena, Isla de Salamanca on 1 December 1969. The skulls lack of post-orbital process; upper and lower molars not erupted, upper incisors trilobulated, and upper canines procumbent. Lower incisors bilobulated, and lower canines peg-liked. Based on the early development of the deciduous teeth series, we assume that these specimens were likely only nursing.

Two additional females (IAvH 3080, IAvH 3091) were collected at Department of Chocó, Ríosucio, Parque Nacional Natural Katios, left margin of Río Peye on 12 August 1976. The skull of the specimens are similar to those describe above (IAvH 345, IAvH 346), however, the lambdoidal crest is slightly developed and the permanent canines and second upper premolar are erupting. The second upper molar is almost completely erupted but slightly inclined. Lower first molars enlarged (almost the same size of adult specimens). Finally, two juveniles, one male and one female, collected at Department of Casanare, Orocué (ICN 787, ICN 788) on April–May 1959, are larger than previous specimens described above and exhibit upper incisors, canines, premolars and first upper molars erupted.

The fact that two cubs were rescued as well that all juvenile specimens are in groups of two for each locality provided some information about the litter size and periods of reproduction of *P. cancrivorus* in Colombia. We found no information about litter size of *P. cancrivorus* from Colombia, however, the species has a reduced litter size (three per litter in Brazil; Forero-Medina *et al.* 2009), in comparison with *P. lotor* (Mugaas *et al.* 1993) in which mean litter size in different samples from North America range from 1.9 to 5.0 (Lotze & Anderson 1979).

In general, little is known about the ecology and natural history of Crab-eating raccoon and other small carnivores of Colombia, and it is necessary to develop research on those topics.

Acknowledgements

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First sympatric records of Coatis (*Nasuella olivacea* and *Nasua nasua;* Carnivora: Procyonidae) from Colombia

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Abstract.
Coatis are among the most unknown small carnivore species in Colombia; even when all coati species have wide distributions, still many aspects of their ecology still need to be explored. Here we present the first confirmed records of sympatry between *Nasua nasua* and *Nasuella olivacea* for Colombia and their entire range. Using camera traps at different distances from Chingaza National Natural Park between August and November 2015 (1,367 trap-nights), we obtained fours records for *N. nasua* and two records for *N. olivacea*, with one locality shared by both species. So far, no confirmed records existed for two sympatric coati species, and all were considered to have disjunctive, non-overlapping distributions. This finding opens a wide range of new ecological questions, in order to understand how this species compete or share the same habitats, and the underlying traits and process that allow this type of sympatric distributions. We expect that with the growing number of field research efforts, especially with camera-traps, new information will be available about the ecology of both species and likely new localities will record both species using the same spaces.

Keywords: Andes, Cundinamarca, Mountain Coati, South American Coati, sympatry

Resumen.
Los cusumbos están entre las especies menos conocidas en Colombia; incluso cuando todos los cusumbos tienen amplias distribuciones en el continente, todavía muchos aspectos de su ecología requieren ser explorados. Presentamos los primeros registros de simpatría entre *Nasua nasua* y *Nasuella olivácea* para Colombia y todo su rango de distribución. Por medio de cámaras-trampa a diferentes distancias del Parque Nacional Natural Chingaza, entre agosto y noviembre de 2015 (1,367 noches-trampa) obtuvimos cuatro registros de *N. nasua* y dos registros de *N. olivácea*, con una localidad compartida por ambas especies. Hasta ahora, no existían registros confirmados de dos especies de Coati simpátricos, y todos eran considerados con distribuciones disyuntas y no sobrepuestas. Este hallazgo abre un amplio rango de preguntas ecológicas nuevas, con el fin de entender como las especies compiten o comparten el hábitat y los procesos y caracteres subyacentes que permiten este tipo de distribuciones simpátricas. Esperamos que con el creciente número de esfuerzos de campo, especialmente con cámaras trampa, nueva información estará disponible sobre la ecológica de ambas especies y es esperable que surjan nuevas localidades de registro de ambas especies usando los mismo espacios.

*Palabras clav*e: Andes, Cundinamarca, Cusumbo de montaña, Cusumbo rojo, simpatría

Introduction

Coatis, genera *Nasua* and *Nasuella* (Procyonidae), are among the most unknown small carnivore species in Colombia and the Americas, with only information regarding distribution records but few ecological or natural history information (Balaguera-Reina *et al.* 2009, González-Maya *et al.* 2011a, Suárez-Castro & Ramírez-Chaves 2015). For Colombia even information regarding presence in the country was uncertain for some

species (*i.e.*, *Nasua narica*; González-Maya *et al.* 2011b), and recent taxonomic and phylogenetic analyses have provided with updated, yet based on few records, distribution of some of the species for the country (*e.g.*, *Nasuella olivacea*; Helgen *et al.* 2009). Coatis have presumably wide distributions both at continent and Colombia-level, with three species confirmed for the country (*i.e.*, *Nasua nasua*, *N. narica* and *Nasuella olivacea*; Solari *et al.* 2013) and one potentially present yet not confirmed with specimens but only recent observations (*i.e.*, *Nasuella meridensis*; Vela-Vargas unp. data). In general, most species are considered as ecologically similar, and current information suggests all species have disjunct, halopatric distributions in the country, with all species reaching the limits of their respective ranges in the country, and most of them conspicuous representatives of different ecosystems (Suárez-Castro & Ramírez-Chaves 2015). Considering the wide range of habitats, considerably large ranges and certain tolerance to intervention (Emmons & Helgen 2008, Reid & Helgen 2008, Samudio *et al.* 2008), and overlapping elevation range for all species, it is likely some overlapping areas could occur where at least two of them could potentially be sympatyric; however, so far, no information exists regarding two Coati species using the same habitats. Here we present the first records of sympatric Coaties, *Nasuella olivacea* and *Nasua nasua*, for Colombia, and to our knowledge of the continent, derived from field records with camera-traps in the eastern Andean mountain range, Guavio region, nearby Bogota, capital city of Colombia.

Materials and methods

Study area

Our field site is located approximately 68 km from Bogotá, within the Guavio region in the Cundinamarca department (province), located in the eastern range of the Andes (Figure 1). Specifically our study covered the Medina and Gachalá municipalities within the Cundinamarca department, and under the jurisdiction of the Corporación Autonoma Regional del Guavio (CORPOGUAVIO; regional environmental authority), in the buffer zone of Chingaza National Natural Park (Chingaza NNP). The area is considered a unique biodiversity region given that includes a significant proportion of Andean and Piedmont ecosystems, and a large elevation gradient from Paramo areas around 4,500 m asl down to 300 m asl on the Llanos piedmont (Vela-Vargas *et al.* 2015). The region has suffered a significant land-use change and habitat loss due mainly to the expansion of the agricultural and cattle frontier expansion, interventions derived from a dam construction (Guavio dam), currently retaining approximately only 22% of its territory under natural forest covers (Vela-Vargas *et al.* 2015). Nevertheless, current efforts for conservation planning in the region are focusing on generating functional connectivity between Chingaza NNP and surrounding areas, both by creating regional protected areas and functional landscapes through co-benefit programs with local communities (Vela-Vargas *et al.* 2015).

Methods

A camera-trapping systematic survey was designed in order to estimate the influence of landscape variables and current limitations for habitat connectivity for carnivore species along the jurisdiction of CORPOGUAVIO, including Chingaza NNP as a potential source for carnivore populations (Vela-Vargas *et al.* 2015). The design included a total of 16 camera-traps (Bushnell Trophy Cam) located on different forest patches at different buffer distances from Chingaza NNP (2, 4, 6 and 8 km), covering an elevation from 1,275 to 2,491 m asl, all located within the transition between Clouded Andean forests and Paramo ecosystems. The cameras were established on random locations selected within each treatment and within potential connection routes between Chingaza NNP and surrounding areas north of the park. All cameras were located on existing animal trails at 30 cm above ground and configured for three photos, delay of 10 second and active during the 24h day cycle; we considered independent records those with at least 1 h difference (González-Maya *et al.* 2009). We estimated the proportion of forested habitats within the habitat context by estimating forest cover within a 5 km buffer of the camera location and based on the national land-cover layer (IGAC 2010).
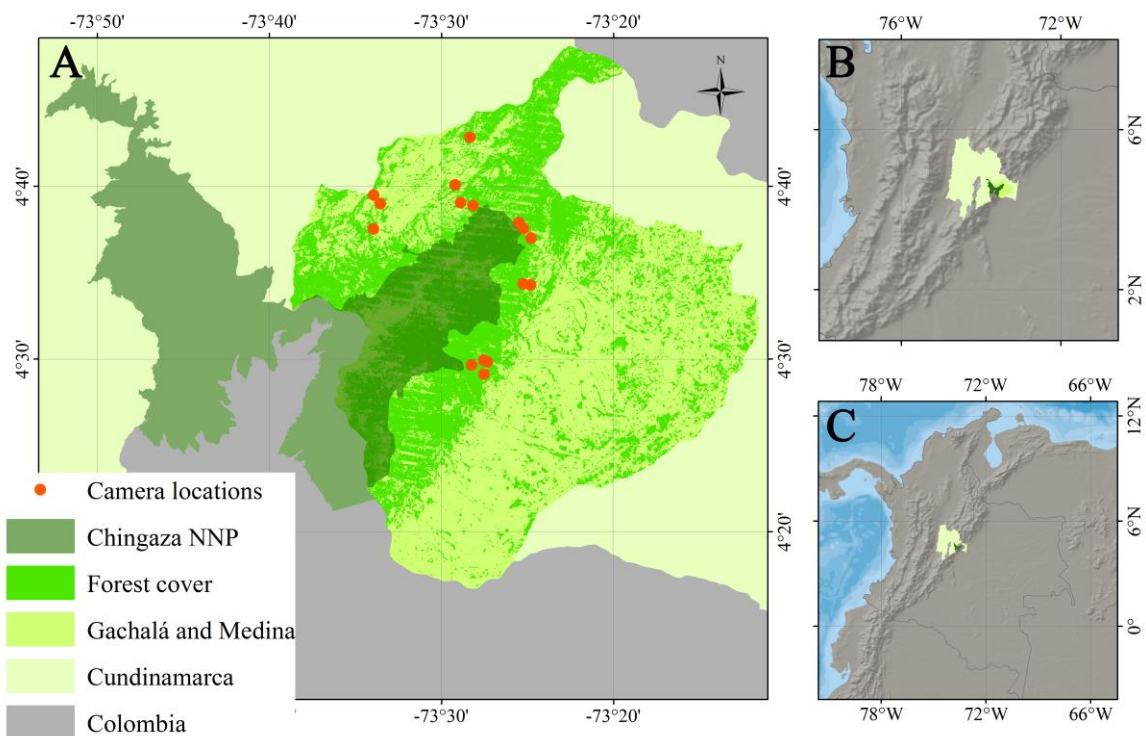
Figure 1. (A) Location of cameras and study area in the context of the (B) Eastern Andes range and (C) Colombia for carnivore connectivity in Guavio region, Colombia.

Results

A total of 1,367 trap-nights sampling effort was held between August and November 2015, obtaining 351 positive events of 18 different mammal species, distributed in six orders. Nine carnivore species were detected, including four felid species (*Puma concolor*, *Leopardus pardalis*, *L. wiedii* and *L. tigrinus*), two mustelids (*Eira barbara* and *Galictis vittata*), one mephitid (*Conepatus semistriatus*) and two procyonids (*Nasuella olivacea* and *Nasua nasua*). From these, only one carnivore species is considered under a threat category by the IUCN Red List of Threatened Species (IUCN 2014; *L. tigrinus*: Vulnerable; de Oliveira *et al.* 2008), one Data Deficient (*N. olivacea*; Reid & Helgen 2008), and the rest are considered as Least Concern (IUCN 2014). In total, we obtained six positive events of Coatis in four localities, four pictures of *Nasua nasua* and two pictures of *Nasuella olivacea*, all located between 2 and 4 km buffers from Chingaza NNP and in both municipalities. We also include three records of *N. olivacea* obtained during 2014 on a similar project in the same area only for future reference.

All Coati records were obtained between September and November 2015, with the first record for *N. olivacea* obtained on 17 September and located at Periquito locality, and the first record for *N. nasua* obtained on 7 October and located at Gachalá locality (Table 1). Even when both species potentially occur in sympatry along the study region, the only confirmed sympatric records of both species at the same site were obtained at Periquito locality, Medina municipality (4.49903 N, 73.45867 W) at 1,934 m asl, with the record for *N. olivacea* obtained on 17 November and the record for *N. nasua* on 9 November (Table 1, Figure 2).

Table 1. Records of *Nasua nasua* and *Nasuella olivacea* in Guavio region, Colombia, with the first confirmed sympatric record for the country (*).

Species	No. of records	Date	Time	Locality	Municipality	Coordinates	Elevation (m asl)	Habitat
N. nasua	1	9Nov2015	13h24	Periquito	Medina*	4.49903 N 73.45867 W	1,934	Dense Natural Forest
	2	11Nov2015 6Nov2015	11h13 19h33	Gachalá	Gachalá	4. 49407 N 73.47065 W	1,539	Dense Natural Forest
	1	7Oct2015	10h15	Gachalá	Gachalá	04. 66814 N 73.48663 W	1,824	Shrubland
N. olivacea	1	17Nov2015	13h22	Periquito	Medina*	4.49903 N 73.45867 W	1,934	Dense Natural Forest
	1	17Sep2015	5h04	Gachalá	Gachalá	4.64804 N 73.4693 W	2,381	Dense Natural Forest
	1	24Dec2014	00h15	Cerro Ají	Ubalá	4.77525 N 73.54744 W	2,729	Dense Natural Forest
	2	7Dec2014 7Dec2014	9h34 17h49	Las Delicias	Ubalá	4.79793 N 73.54341 W	3,090	Dense Natural Forest
	1	7Dec2014	4h51	Cerro Ají	Ubalá	4.77608 N 73.54684 W	2,728	Dense Natural Forest

Other species deteced at the same site include the Mountain Paca *Cuniculus taczanowskii*, Red-tailed Squirrel *Sciurus granatensis*, Tayra *Eira barbara*, Puma *Puma concolor* and Ocelot *Leopardus pardalis*. Capture frequencies (pictures/sampling effort)

was similar for all species, with *E. barbara* and *L. pardalis* been the species most detected on the site (0.0029 pictures/trap-night). Domestic dogs *Canis familaris* were detected in two of the three localities were *N. nasua* was detected, and were not captured at any of the two sites were *N. olivacea* occurred. Interestingly, the site were both species were detetected has the highest proportion of forested habitat within the buffer (89.2%), while the mean proportion (± SD) of forest for all sites with Coati detections was 58.9 ± 31.6% (64.6 ± 36.1% for *N. nasua* and 61.6 ± 28.1% for *N. olivacea*) and without Coati 69.7 ± 21.2%. Mean distance of camera-traps with coati detections to rivers and roads (± SD) was 664.1 ± 458.0 and 4,103.4 ± 1,706.2 m, respectively (*N. nasua*: rivers = 871.8 ± 235.8 m, roads = 4,334.3 ± 2,011.5; *N. olivacea*: rivers = 341.6 ± 425.65, roads = 4,348.0 ± 1,325.9) and 667.92 ± 472.13 and 3,950.3 ± 2,138.8 m for rivers and roads in non-coati sites, respectively.

Figure 2. Sympatric record obtained through pictures from camera-traps of (A) *Nasuella olivacea* and (B) *Nasua nasua* in Guavio region, Cundinamarca department, Colombia.

Discussion

We found previous accounts that claim to have sympatric records of both species, also for the Andean region, but do not provide details or extensive accounts on the presence of both species at the same site or specifically in sympatricity (Sánchez *et al.* 2004, 2008, Delgado-V 2009, Ramírez-Mejía & Sánchez 2015), and most of them have not confirmed presence for at least one of the species (*e.g.*, based on tracks, observations, etc.). Nevertheless, considering Colombia is one of the only countries where sympatric coati species could occur, these previous records or inferences indicate that potentially other areas could represent areas of potential range overlapping among coatis, all of them in the Andes. *Nasua nasua* is considered to be distributed across most of South America (Samudio *et al.* 2008), and for Colombia is considered to be distributed in the Amazon, Andes and Orinoco regions between 0 and 3,600 m asl (Solari *et al.* 2013); *N. olivacea* is distributed in Colombia, potentially Peru and Ecuador (Helgen *et al.* 2009) and in Colombia is reported for the Andean region and Serranía del Perijá between 1,700 and 4,100 m asl (Solari *et al.*

2013). Even when both distributions overlap significantly, so far no records of both species occupying the same habitats have been obtained or confirmed. The third confirmed species, *Nasua narica*, is only confirmed for the Pacific region, having the southernmost limit of its distribution in Colombia (González-Maya *et al.* 2011), therefore, there are currently no areas, based on current knowledge, that any of the other two species share with *N. narica* in the country, nor across their distribution.

Ecologically, both species have similar requirements, with *N. nasua* having a significant wider ecological plasticity, occupying a considerable larger number of habitats (Suárez-Castro & Ramírez-Chaves 2015); *N. olivacea* is restricted to the Andes, mostly associated with high-Andean forests and the lower limits of Paramos (Rodríguez-Bolaños *et al.* 2000, Rodríguez-Bolaños *et al.* 2003, Balaguera-Reina *et al.* 2009). Few information exists regarding foraging and diet (Rodríguez-Bolaños *et al.* 2000), but it seems both species share similar traits and dietary compositions (Rodríguez-Bolaños *et al.* 2000, Beisiegel 2001, Rodríguez-Bolaños *et al.* 2003, Alves-Costa *et al.* 2004, Suárez-Castro & Ramírez-Chaves 2015). It is not clear how both species can share or compete within the same habitat, and our records, even when few, do not seem to reflect any differential time-use within the same habitat. Further research is needed in order to better understand how both species can share de same habitat or if competition exists for resources or space. This finding opens a wide range of ecological questions that we expect will promote to further explore the ecology of both species and their functional role in Andean ecosystems.

The significant increase of camera-trap efforts across the continent, and especially in Colombia, are providing a large number of records for both species, but still, both are still considered as neglected species with few studies focused on assessing their status, ecology or distribution, or with valuable information never published or considered (Schipper *et al.* 2009, González-Maya *et al.* 2011). Furthermore, for Colombia, social conflict and general civil violence across the country prevented many areas to be properly studied or explored and is not until recently that a significant number of studies are focusing on filling the geographic and taxonomic gaps, which in a few years will allow drawing better inferences regarding the distribution of most medium and large size mammals, especially carnivores, in the country. It is expected that in coming years similar records like the one presented herein will be available from research efforts across the country; nevertheless, this record provides valuable information for starting to better understand the ecology and importance of mesocarnivores in tropical ecosystems, especially on the sight of more dramatic and larger disturbances in most ecosystems across the country.

Acknowledgements

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Distribution and conservation status of Honey Badgers *Mellivora capensis* in Iran

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Abstract.

The Honey Badger or Ratel *Mellivora capensis*, which is distributed over much of Africa, the Middle East, Central and South Asia, is one of the rarest carnivores in Iran. This report reviews the historical records in Iran coupled with the inclusion of a number of more recent sightings in parts of the country where Honey Badgers had formerly not been documented – notably in around Khoramshahr, Ramhormoz, Shush, Dezful, Rafsanjan and Baft. Between 2008 and 2014, at least 14 individuals and a family group of Honey Badgers were recorded from 13 localities, of which four were killed outright by local people, two were camera-trapped, five were recorded by direct observation, two were live-trapped and released, one was killed in a road accident and a family group was captured by video. The Honey Badger is not adequately protected in Iran. Habitat destruction, poisoned baits, trapping and poaching are important threats to the species. In southwest and central Iran, the species is also sought after for its fat which is used in traditional medicine.

Keywords: conservation, Honey Badger, Iran, *Mellivora capensis*, poaching, Ratel, record, threat

پراکندگی و وضعیت حفاظتی رودک عسلخوار در ایران
چکیده.
رودک عسلخوار که یکی از کمیاب‌ترین گوشتخواران ایران محسوب می‌شود، در آفریقا، خاورمیانه و آسیای مرکزی پراکندگی وسیعی دارد. این گزارش، پیشینه تاریخی رودک‌عسلخوار را در بخش‌هایی از کشور بررسی کرده و مشاهدات جدید آن در خرمشهر، رامهرمز، اطراف شوش، دزفول، رفسنجان و بافت که پیش‌تر منتشر نشده را ارائه می‌دهد. بین سال‌های دوهزار و هشت تا دوهزار و چهارده میلادی، حداقل چهارده فرد و یک خانواده از رودک عسلخوار در سیزده محل مختلف مشاهده شده‌اند. چهار فرد از آن‌ها به طور واضح توسط مردم محلی کشته، دو فرد با دوربین تله‌ای، پنج فرد هم به صورت مشاهده مستقیم و یک فرد در تصادف جاده‌ای ثبت شدند و دو فرد از آن‌ها نیز زنده‌گیری و رهاسازی شده‌اند. علاوه بر این، یک خانواده رودک نیز به وسیله یک فیلم ثبت شد. رودک عسلخوار به اندازه کافی در ایران حمایت نمی‌شود. تخریب زیستگاه، طعمه‌های مسموم، زنده‌گیری و شکار غیرمجاز مهم‌ترین تهدیدهای این گونه است. همچنین چربی این گونه در جنوب غربی و مرکز ایران به عنوان داروی سنتی خواستار دارد.

واژگان کلیدی: ایران، تهدید، حفاظت، رکورد، رودک‌عسلخوار، شکار غیرمجاز

Introduction

The Honey Badger or Ratel *Mellivora capensis* (Schreber, 1776) is the only species of the genus *Mellivora* and has one of the largest distribution areas in the Mustelidae family (Heptner & Naumov 1967). The species is native to Africa from the Cape of Good Hope in the Western Cape Province of South Africa to Somalia, Ethiopia, and Sudan in the east and to Morocco in the west. Beyond Africa, its range extends through the Middle East from Israel to Iran, Central Asia from Turkmenistan to southwest Kazakhstan, Pakistan, India

and Nepal in South Asia (Harrison & Bates 1991, Vanderhaar & Hwang 2003, Mallon & Budd 2011). The Honey Badger is listed as Least Concern by IUCN (Begg *et al.* 2008) and in the Appendix III of the CITES.

Honey Badgers were recorded from some localities between the Amu-Darya River and the Caspian Sea in Turkmenistan. From these localities, a few records were found along the Atrek (Atrak) River, Kopet-Dag plains, and Tedzhen (Tedjen) River near the Iranian border (Heptner *et al.* 1967). Iran was included in the Honey Badger distribution range by Misonne (1959), who noted its presence in Khuzestan and Golestan provinces (Figure 1). Until 2008, it was recorded in Khuzestan Province to the northwest of Ramhormoz, between Ahwaz and Shush, and reported from Golestan Province around Gorgan and along the Atrak River (Misonne 1959). Ziaie (2008) contributed several new records for the species in Iran. One additional record was made by Joolaee *et al.* (2012).

This short paper examines the current distribution and threat status of the Honey Badger in Iran by combining a literature review from 1959 to 2012 (Misonne 1959, Etemad 1985, Ziaie 2008, Joolaee *et al.* 2012, Karami *et al.* In prep; Table 1) with several new records obtained by the first author from the Iranian Department of the Environment from 2012 to 2014. Some records of the species resulted from poaching in Khabr National Park and Dadin Area, while others were confirmed by photo and video materials from Boroeiyeh Wildlife Refuge (Ziaie 2008, Joolaee *et al.* 2012) and other regions (Figure 2).

Records of *M. capensis* in Iran

Old records: 2008–2012

- The one member of a family group of Honey Badgers was killed by local people in Khabr National Park, 37 km to the south of Baft town. It was the first record of Honey Badgers in Kerman Province (Ziaie 2008).

- The first evidence of the species in Yazd Province was recorded in Boroeiyeh Wildlife Refuge, which is located in Khatam County, when a family group of Honey Badgers was documented in a video (Ziaie 2008). The second sighting was made in Kalmand Protected Area and the third was around Tangchenar village, located at the edge of Aliabad Protected Area, westward of Kalmand Protected Area (Karami *et al.* In prep.).

- The first record in Fars Province was a Honey Badger killed by local people from Sar Mashhad village, Dadin area, located 120 km southwest of Shiraz city and 32 km to the south of Kazerun town (Joolaee *et al.* 2012).
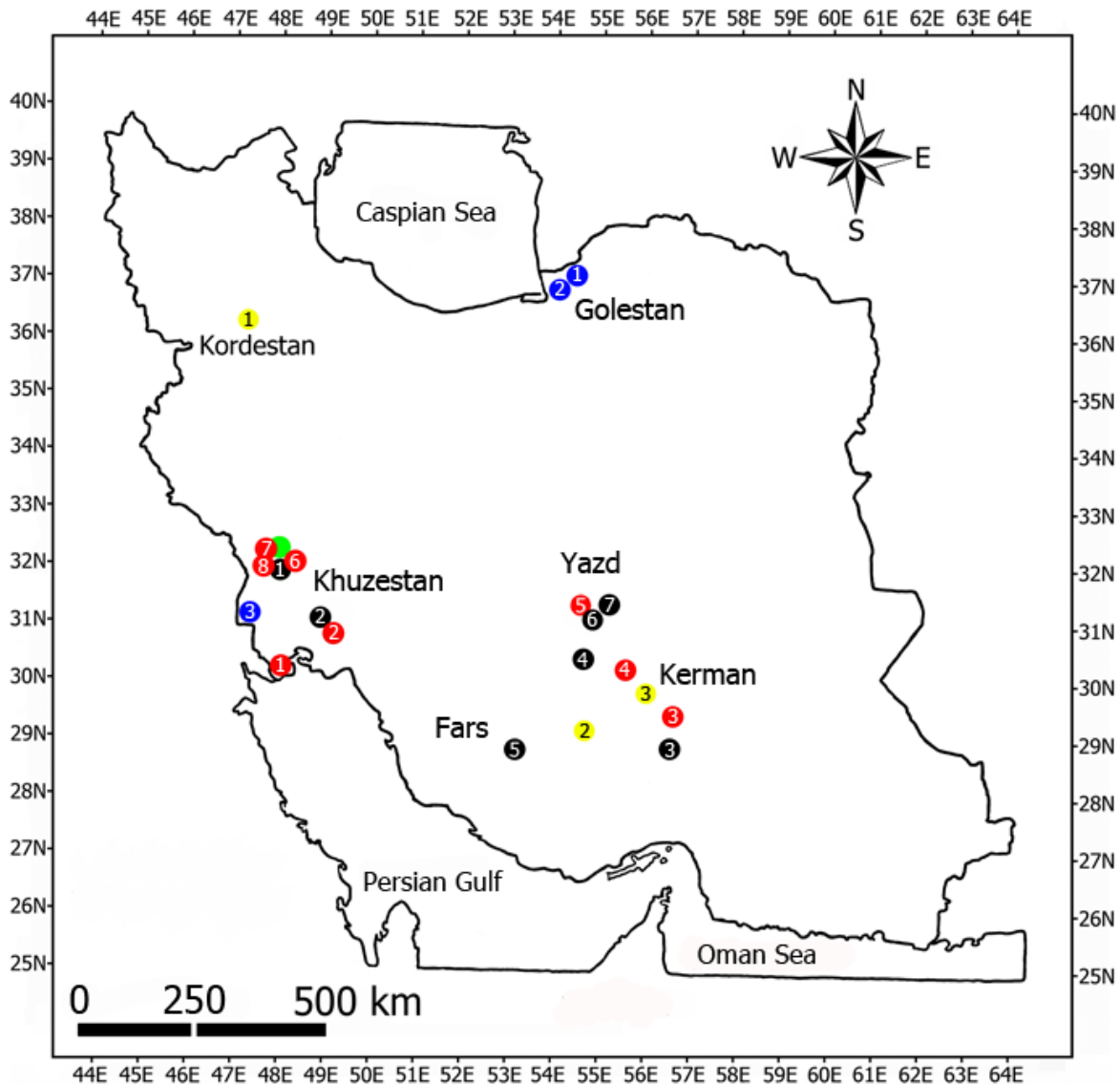
Figure 1. Current distribution of Honey Badger *Mellivora capensis* in Iran. Blue dots: old records by Misonne (1959) near Atrak River from Golestan in northeast (numbers 1 and 2) and near Iraq–Iran border in the southwest of Khuzestan (3). Green dot: unpublished record by Joslin in 1974 from Dez-Karkheh Area in Khuzestan (see Fig. 2). Black dots: recent records by Etemad (1985) between Ahwaz and Shush (1) and near Ramhormoz (2) in Khuzestan; Ziaie (2008) from Khabr National Park (3) in Kerman and Boroeiyeh Wildlife Refuge (4) in Yazd; Joolaee *et al.* (2012) from Dadin in Fars (5); Karami *et al.* (in press) from Aliabad Protected Area (6) and Kalmand Protected Area (7). Red dots: Khoramshahr (1), Ramhormoz (2), Baft (3), Mansourabad near Rafsanjan (4), Mehriz (5), Mianroud (6), Naderi village (7) and Helveh village (8) were new records by the Iranian Department of the Environment from 2012 to 2014. Yellow dots: unconfirmed records in Bijar Protected Area (1), Bahram-e Gur Wildlife Refuge (2) and Gughar Area (3).
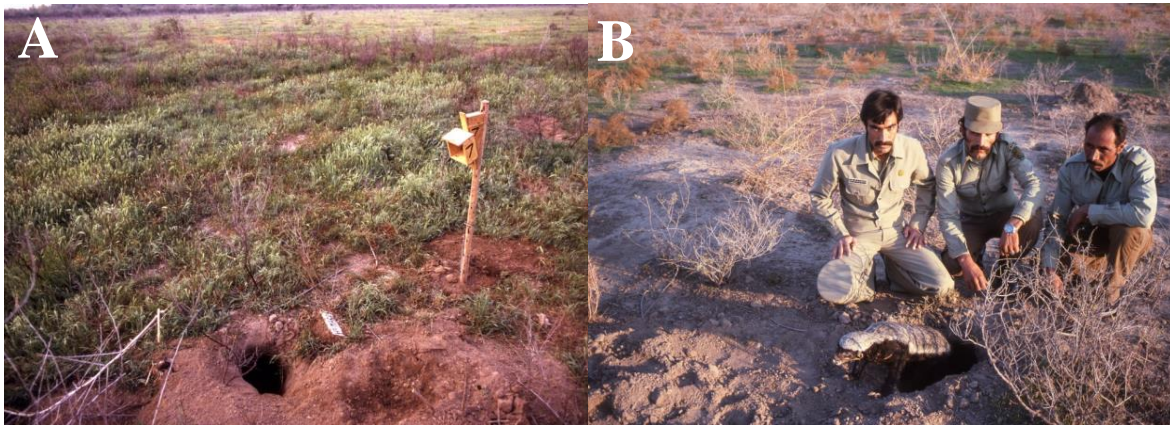
Figure 2. (A) A camera-trap set to record Honey Badgers in Dez-Karkheh Area in 1974 and (B) taxidermy of a dead Honey Badger killed in a road accident in Dez-Karkheh Area in 1974 (Photos: P. Joslin).

Recent records: 2012–2014

- The second and third records of the species in Yazd Province were camera-trap captures to the southeast and south of Mehriz town, during December 2012.

- In September 2013, a subadult Honey Badger was live-trapped near Khorramshahr city in Khuzestan Province. It was transferred to the Khorramshahr office of the Department of the Environment and was released a few days later in the area where it had been caught.

- In 2013, one adult Honey Badger was sighted around Helveh village near Karkheh National Park and another one was observed around Mianroud town near Dez National Park.

- In February 2014, two adult Honey Badgers were killed by local poachers in the vicinity of Baft (Figure 3). This was only the second time that the species had ever been recorded in Kerman Province.

- In March 2014, a rancher trapped a subadult Honey Badger near Ramhormoz town in Khuzestan Province. It was transferred to the Department of the Environment office in Ramhormoz and then returned to its den.

- In March 2014, a Honey Badger was sighted by a group of environmentalists near Mansurabad, 46 km to the west of Rafsanjan town. This record was the first evidence of the species in Rafsanjan County and only the third record from Kerman Province.

- In 2014, one road kill of an adult *M. capensis* was recorded from Mianroud town by the last author. Also, game wardens of Khusestan Province sighted a Honey Badger around Naderi village, 20 km west of Dezful and 21 km north of Shush.

- Three unconfirmed records occurred in Bijar Protected Area (Kordestan Province), Bahram-e Gur Wildlife Refuge (Fars Province) and Gughar Area (Kerman Province; Table 1).

Table 1. Records (1959–2014) and poaching risk of Honey Badger Mellivora capensis in different provinces of Iran.

Records	Khuzestan	Kordestan	Fars	Kerman	Yazd	Golestan
Number of poached individuals	2 live-trapped	0	1 killed	3 killed	0	0
Number of records outside protected areas	7	0	1	4[c]	0	2
Number of records from protected areas	3	1[a]	1[b]	1	3	0
Number of road kills	2	0	0	0	0	0
Risk of poaching	High	Unknown	High	High	Low	Low

[a] An unconfirmed record in Bijar Protected Area from Kordestan Province (Fig. 1); [b] an unconfirmed record in Bahram-e Gur Wildlife Refuge from Fars Province (Figure 1); [c] three individuals in two records, and an unconfirmed record in Gughar Area northwest of Baft (Figure 1).

Figure 3. Two poached Honey Badgers in Baft town (Photo: Iran Environment and Wildlife Watch).

Current status, threats and conservation

Honey Badgers were documented in 20 localities during 1959–2014 (Figure 1; Table 1). The sample of old and recent records indicates that the Honey Badger is distributed in southwestern, southern, central and northeast parts of Iran within the provinces of

Khuzestan, Fars, Kerman, Yazd and Golestan. Poaching of this species has been documented in recent years in some protected and unprotected areas (Ziaie 2008, Joolaee *et al.* 2012). While not assessed in this study, poisoned baits and habitat destruction by overgrazing, mining and extension of farmlands and human communities (Figure 4) are also considered as threats. Some level of conflict between gardeners and Honey Badgers has been reported. There is no information on the population status or biology of this species in Iran. The Honey Badger is one of the rarest mammals in Iran, but it is not protected by the Iranian Department of the Environment, and its fat is used in traditional medicine (Ziaie 2008, Karami *et al.* In prep.). Looking at Iran as a whole, while this mustelid may be secure in Yazd and Golestan provinces, poaching and other threats need to be taken into account in Khuzestan, Fars and Kerman provinces. The Honey Badger is a vulnerable species outside of the Iranian protected areas (Table 1).

Figure 4. A view of extension of croplands around Dez and Karkheh National Parks; one of the most important areas for Honey Badgers in Iran (Source: Google Earth 2015).

Acknowledgements

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Corrigendum
Volume 51

Wan J. P. H. 2014. Intake of an ethnomedical shrub by Yellow-bellied Weasel *Mustela kathiah*. *Small Carnivore Conservation* 51: 34–37.

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