

# Notes on the distribution and status of small carnivores in Gabon

Laila BAHAA-EL-DIN<sup>1,2,3\*</sup>, Philipp HENSCHL<sup>1\*</sup>, Rostand ABAA<sup>4</sup>, Kate ABERNETHY<sup>5,6</sup>, Torsten BOHM<sup>7</sup>, Nicolas BOUT<sup>4,8</sup>, Lauren COAD<sup>9</sup>, Josephine HEAD<sup>10</sup>, Eiji INOUE<sup>11</sup>, Sally LAHM<sup>12</sup>, Michelle E. LEE<sup>2,6</sup>, Fiona MAISELS<sup>4,5</sup>, Luisa RABANAL<sup>10</sup>, Malcolm STARKEY<sup>4</sup>, Gemma TAYLOR<sup>9</sup>, Hadrien VANTHOMME<sup>13</sup>, Yoshihiro NAKASHIMA<sup>11</sup> and Luke HUNTER<sup>1</sup>

## Abstract

The distribution and status of small carnivore species in Gabon have never been comprehensively assessed. We collated data from general wildlife surveys, camera-trap and transect studies and analyses of bushmeat consumption and trade, to map their country-wide occurrence and assess current exploitation levels. Records of Common Slender Mongoose *Herpestes sanguineus* and Cameroon Cusimanse *Crossarchus platycephalus* represent the first confirmation of their occurrence in Gabon. Cameroon Cusimanse was believed to extend into north-east Gabon, but the Slender Mongoose records extend its known range well outside that previously suspected. We furthermore extended the known range for Egyptian Mongoose *Herpestes ichneumon*. Crested Genet *Genetta cristata* has also been proposed to occur in Gabon but our records were not suited to evaluating this possibility given the difficulties of separation from Servaline Genet *G. servalina*. Most species appear to be distributed widely across the country. While several are commonly recorded in hunter catch and bushmeat markets, they form only a small proportion (3.4% and 3.1%, respectively) of all bushmeat records. However, in proximity to settlements, small carnivore exploitation, for bushmeat and use of body parts in traditional ceremonies, appears to have adverse effects on species richness and abundance.

*Keywords:* bushmeat, camera-trap, *Crossarchus platycephalus*, distribution, *Herpestes ichneumon*, *Herpestes sanguineus*

## Notes sur la distribution et le statut des petits carnivores au Gabon

### Résumé

La distribution et le statut des petits carnivores n'ont jamais été évalués en détails au Gabon. Nous avons utilisé des données provenant d'études de suivi de la faune, par pièges-photos et transects, ainsi que des analyses sur la consommation et le commerce de la viande de brousse, afin de cartographier leur présence au Gabon et d'évaluer leur niveau d'exploitation actuel. Nos résultats établissent la présence de la Mangouste rouge *Herpestes sanguineus* et du Crossarque à tête plate *Crossarchus platycephalus* au Gabon, représentant les premières données confirmées de ces deux espèces dans ce pays. Si la présence du Crossarque à tête plate au nord-est du Gabon était déjà soupçonnée, celle de la Mangouste rouge n'était pas connue au Gabon et nos données élargissent considérablement son aire de répartition. Nous avons également enregistré une extension de la distribution de la Mangouste d'Égypte *Herpestes ichneumon*. La Genette à crête *Genetta cristata* fût proposée comme présente au Gabon, mais nos observations ne permettent pas de confirmer cette hypothèse compte tenu de la difficulté de la différencier morphologiquement de la Genette servaline *G. servalina*. La majorité des espèces semblent être largement diffusées dans tout le pays, et bien que plusieurs espèces soient couramment observées dans les prises des chasseurs et les marchés de viande de brousse, elles ne constituent qu'une petite partie (3,4% et 3,1%, respectivement) des espèces capturées. Cependant, à proximité de villages, l'exploitation des petits carnivores pour la consommation de viande de brousse et l'utilisation de parties du corps dans les cérémonies traditionnelles semble avoir des effets défavorables sur la diversité et l'abondance des espèces.

*Mots clés:* *Crossarchus platycephalus*, *Herpestes ichneumon*, *Herpestes sanguineus*, piège-photo, répartition, viande de brousse

## Introduction

The African rainforest harbours a diverse guild of small carnivores, of which several species are endemic to Equatorial such forests (Ray 2001). Gabon is on the west coast of Central Africa (Fig. 1), with a low human population density and large tracts of rainforest that cover 85% of the country (Ernst *et al.* 2012). The importance of Gabon for the conservation of threatened taxa has been highlighted for a number of larger species (e.g. Walsh *et al.* 2003, Blake *et al.* 2007, Henschel *et al.* 2011), and it might be equally important for the conservation of small carnivores. While several studies investigated the feeding habits of individual small carnivore species (e.g. Charles-Dominique 1978, Emmons *et al.* 1983), there have been no comprehensive efforts to

date to assess the status and distribution of all small carnivore species occurring in Gabon.

Most wildlife surveys in Gabon have concentrated on general biodiversity monitoring, with several focusing on primates, elephants *Loxodonta* and cats (Felidae). Fortunately, data on small carnivores have been collected opportunistically over the course of several such surveys. In addition, a recent boom in the use of remotely-triggered camera-traps for wildlife surveys in Gabon has meant that many carnivore data have been gathered incidentally. Here we collate opportunistic observations of small carnivores obtained during general wildlife and species-specific surveys and data from 16 different camera-trap study sites across Gabon, to assess the current distribution of small carnivores in this country. To explore how these

species may be affected by the bushmeat crisis sweeping West and Central Africa (see Fa & Brown 2009), we investigated available bushmeat offtake data from 65 villages across Gabon and bushmeat trade data from 11 towns throughout the country.

## Methods

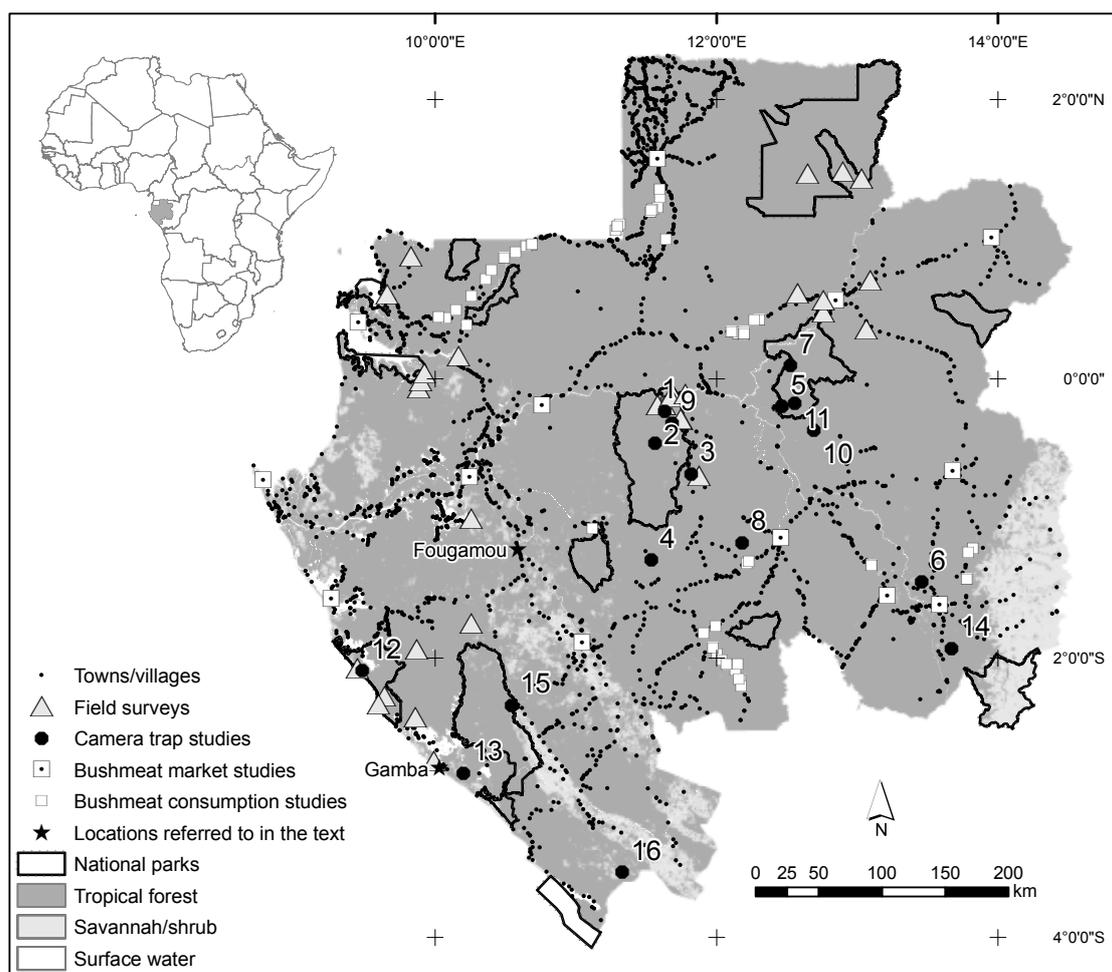
### Study area

Gabon is a central African country that straddles the equator and borders the Atlantic Ocean (Fig. 1). The habitat in Gabon consists predominantly of moist tropical forest, with savannah, swamps and mangroves making up about 15% of the land area (Fig. 1) (Lahm 2001, Ernst *et al.* 2012). The human population is small (1.6 million) and largely urban (86% of population) (CIA 2012). This, coupled with a relatively strong economy supported by natural resource extraction, has meant that Gabon has not suffered from landscape degradation similar to that experienced in some other countries in the region (CIA 2012). In 2002, 13 national parks were created, encompassing 30,000 km<sup>2</sup>, or 11% of the country's land surface (Fig. 1).

### Study species

Of the species under the remit of the IUCN SSC Small Carnivore Specialist Group, nine had been recorded in a faunal

inventory of Gabon prior to its independence (Malbrant & Maclatchy 1949). Malbrant & Maclatchy (1949) furthermore speculated about the occurrence of Long-nosed Mongoose *Herpestes naso*, Cameroon Cusimanse *Crossarchus platycephalus* and Common Slender Mongoose *Herpestes sanguineus* in Gabon. All 12 species (Table 1) are currently listed as Least Concern on *The IUCN Red List of Threatened Species* (IUCN 2012). As well as these 12, two other species occur in Gabon, Congo Clawless Otter *Aonyx congicus* and Spotted-necked Otter *Lutra maculicollis*, but these are not discussed here except for within the bushmeat data used to make an overall assessment of the hunting pressure on carnivores. Finally, Gaubert *et al.* (2006) recorded Crested Genet *Genetta cristata* for Gabon (and Congo), more than 500 km south of the Sanaga River. These records were considered "equivocal" by Hunter & Barrett (2011: 90) and were mapped only as "?" by Van Rompaey & Colyn (2013d: 223). Crested Genet and Servaline Genet *G. servalina* are morphologically similar and perhaps hybridise (Gaubert *et al.* 2006). Thus, their identification requires care and often they cannot be distinguished on camera-trap images such as form the bulk of our records. Hence, it is possible that the records presented here as 'Servaline Genet' include some that are in fact of Crested Genet, or of hybrids between these two.



**Fig. 1.** Vegetation map of Gabon, showing population centres, protected areas and locations of the various surveys included in this study.

**Table 1.** Distribution and habitat use for the small carnivores of Gabon.

| Species   | Africa distribution <sup>1</sup>  | Habitat   |
|---|---|---|
| Marsh Mongoose <i>Atilax paludinosus</i>              | Most of sub-Saharan Africa  | Dense habitat near water (including watercourses, marshes, mangroves and estuaries) |
| Long-nosed Mongoose <i>Herpestes naso</i>             | Endemic to Equatorial rainforest  | Rainforest, usually near watercourses and in areas with dense understorey           |
| Black-footed Mongoose <i>Bdeogale nigripes</i>        | Endemic to Equatorial rainforest  | Rainforest, with preference for dense understorey                                   |
| Cameroon Cusimanse <i>Crossarchus platycephalus</i>   | Southern Nigeria to northern Gabon  | Rainforest and forest–savannah mosaic   |
| Common Slender Mongoose <i>Herpestes sanguineus</i>   | Most of sub-Saharan Africa  | Most habitats, except true desert   |
| Egyptian Mongoose <i>Herpestes ichneumon</i>          | Most of sub-Saharan Africa, except the north-east, the horn, and parts of Southern and Central Africa | Most open habitats except true desert, including cultivated land                    |
| African Civet <i>Civettictis civetta</i>              | Most of sub-Saharan Africa except the extreme south   | Most habitats with cover, except very arid areas; including cultivated land         |
| Servaline Genet <i>Genetta servalina</i> <sup>2</sup> | Endemic to Equatorial rainforest  | Rainforest and dense woodland   |
| Rusty-spotted Genet <i>Genetta maculata</i>           | Most of sub-Saharan Africa, except the extreme south  | Forest (including rainforest), woodland and moist savannah                          |
| Central African Oyan <i>Poiana richardsonii</i>       | Endemic to Equatorial rainforest  | Rainforest  |
| African Palm Civet <i>Nandinia binotata</i>           | Endemic to Equatorial Africa  | Rainforest, forest–savannah mosaics and dense woodland                              |
| Honey Badger <i>Mellivora capensis</i>                | Most of sub-Saharan Africa  | All habitats; requires cover  |

Sources: Hunter & Barrett (2011), IUCN (2012).

<sup>1</sup> See Fig. 3.

<sup>2</sup> Crested Genet *G. cristata* has also been reported from Gabon, but subsequent authors have called for corroboration (see text).

### Mapping of species distribution

We collated data from 33 wildlife field surveys and 16 camera-trap studies (Table 2, Fig. 1), and plotted confirmed small carnivore records to assess the distribution of each species. In addition, we used bushmeat hunting records for which the species and the site of catch could be confirmed, as well as faecal DNA records from a study in Moukalaba-Doudou National Park (NP). Faeces were identified to species level using a part of the mitochondrial cytochrome b which was amplified according to the method of Veron & Heard (2000).

Field survey sites were distributed across large parts of Gabon (Fig. 1). Some surveys used line transects conducted by day and at night, with observers walking at about 1 km/h (see Lahm 1993). Camera-trap studies used various camera-trap models and trapping protocols, depending on their aims (Table 2). These differences affect the likelihood of capturing each species and we therefore could not use non-detection (sites where the species were not photo-captured) as strong evidence of absence. We do discuss, however, trends that appear from consistent non-detection in certain areas or habitat types.

Where the species identity was in question, data were discarded. Marsh Mongoose *Atilax paludinosus* and Long-nosed Mongoose posed the greatest difficulty, being closely related and difficult to tell apart in the field (Ray 1997). The best diagnostic feature is the lack of webbing between the toes in Marsh Mongoose (Baker & Ray 2013, Van Rompaey & Colyn 2013c). More visible on images, Marsh Mongoose has a blunt, triangular face, whilst Long-nosed Mongoose has a long muzzle and prominent nose (Hunter & Barrett 2011). The latter

also has a longer and brushier tail (Baker & Ray 2013) that can be seen on certain images (Fig. 2).

*Analysis of small carnivore offtakes through bushmeat hunting*  
Data on village hunting offtakes in Gabon were collated from a number of existing studies, as part of an ongoing study of hunting offtakes across West and Central Africa (Taylor 2012), including data from published and grey literature, as well as unpublished data. We included only studies that provided complete village hunting offtake data (not those covering only a particular family or genus), and that identified animals to species level. Village offtake data were collected using two methods: 1) 'bag counts': hunter offtake was directly recorded on their return to the village from hunting; 2) '3-day recall': households were asked, using a questionnaire, what they had caught in the last three days. Offtakes provided as biomass were converted into number of animals using empirical weights for Gabon in Abernethy *et al.* (2006) and Coad (2007) or, where empirical weights were not available, published weights from Kingdon (1997) or the Pantheria database (Jones *et al.* 2009). For a few bird and rodent species, expert opinion from Gabon was solicited to provide an estimate.

We identified three studies from Gabon (Wilkie *et al.* 2006, Carpaneto *et al.* 2007, Coad 2007), comprising offtake data for 65 villages (Fig. 1). Data from the 'Parks and People' study (see Wilkie *et al.* 2006) accounted for most of these villages ( $n = 56$ ), and come from the surrounds of the then newly-created national parks of Birougou, Monts de Cristal and Ivindo. Sample sizes per village were small (mean of 10 days'

**Table 2.** Camera-trapping protocols at each site in Gabon supplying small carnivore records.

| # in Fig. 1 | Study site <sup>1</sup>            | Study species <sup>2</sup> and aim                        | Year of study | Habitat type   | Human activity   | Principal investigator | Camera-trap type/model                                 | Trap height (cm) | Target areas   |
|-------------|------------------------------------|---|---------------|--|--|------------------------|--|------------------|--|
| 1           | SEGC                               | Leopard ecology   | 2002          | Predominantly Marantaceae forest                           | Research   | P. Henschel            | 35 mm Camtrakker                                       | 40–45            | Game trails  |
| 2           | former SO-FORGA logging concession | Leopard ecology   | 2002          | Formerly logged, secondary forest                          | None   | P. Henschel            | 35 mm Camtrakker                                       | 40–45            | Old logging roads  |
| 3           | NSG concession                     | Leopard ecology   | 2002          | Recently logged, secondary forest                          | Logging  | P. Henschel            | 35 mm Camtrakker                                       | 40–45            | Old logging roads  |
| 4           | Massima                            | Leopard ecology   | 2002          | Pristine, primary forest                                   | Village hunting  | P. Henschel            | 35 mm Camtrakker                                       | 40–45            | Game trails  |
| 5           | Dilo                               | Leopard ecology   | 2003          | Formerly logged, secondary forest                          | Research & Tourism                                       | P. Henschel            | 35 mm Camtrakker                                       | 40–45            | Old logging roads  |
| 6           | Lekabi Ranch                       | Lion survey   | 2003          | Forest/savannah mosaic                                     | Cattle ranching  | P. Henschel            | 35 mm Camtrakker                                       | 40–45            | Roads  |
| 7           | Massouna 2000                      | Leopard ecology   | 2004          | Recently logged, secondary forest                          | None   | P. Henschel            | 35 mm Camtrakker                                       | 40–45            | Old logging roads  |
| 8           | Lolo                               | Leopard ecology   | 2005          | Recently logged, secondary forest                          | Village hunting  | P. Henschel            | 35 mm Camtrakker                                       | 40–45            | Old logging roads  |
| 9           | Mikongo                            | African Golden Cat ecology                                | 2010          | Predominantly Marantaceae forest                           | Research & Tourism                                       | L. Bahaa-el-din        | 35 mm DeerCam & digital DLC Covert II                  | 25–30            | Game trails & old logging roads                          |
| 10          | Milolé                             | African Golden Cat ecology                                | 2011          | Recently logged, secondary forest                          | Logging  | L. Bahaa-el-din        | Digital Panthera & Scoutguard                          | 25–30            | Game trails & old logging roads                          |
| 11          | Langoué                            | African Golden Cat ecology                                | 2011          | Pristine, primary forest                                   | Research   | L. Bahaa-el-din        | Digital Panthera & Scoutguard                          | 25–30            | Game trails  |
| 12          | Loango                             | Ape / elephant population assessment, Chimpanzee tool use | 2009/2010     | Formerly logged, primary forest, coastal forest, mangroves | Research   | J. Head                | Scoutguard & Bushnell                                  | 80–100           | Elephant trails, natural bridges, clearings, swamp edges |
| 13          | Gamba area                         | Impact of roads and other human disturbances on mammals   | 2010/2011     | Littoral savannah/gallery forests/swamp mosaic             | Roads, settlements, oil extraction, agriculture, hunting | H. Vanthomme           | Reconyx RC55 rapid-fire                                | 40–50            | Game trails & transects                                  |
| 14          | SE Gabon                           | Spotted Hyaena survey                                     | 2011          | Forest/savannah mosaic                                     | Hunting, roads, settlements                              | T. Bohm                | Reconyx HC500, Cuddeback Capture & Bushnell 2009, 2010 | 30–40            | Game trails & roads                                      |
| 15          | Moukalaba-Doudou                   | Assessment of species diversity                           | 2010          | Logged secondary forest (1960s–1980s), savannah            | None   | Y. Nakashima           | Bushnell Trophy Cam 2010                               | 25–30            | Random places  |
| 16          | Mayumba                            | Faunal inventory  | 2012          | Formerly logged, primary forest                            | None   | R. Aba'a               | DLC Covert & Reconyx                                   | 30               | Game trails near random grid locations                   |

<sup>1</sup> Locations of camera-trap study sites are shown on Fig. 1. SEGC = Station d'Études des Gorilles et Chimpanzés.

<sup>2</sup> Species: Leopard *Panthera pardus*; Lion *Panthera leo*; African Golden Cat *Profelis aurata*; African Elephant *Loxodonta africana*; Chimpanzee *Pan troglodytes*; Spotted Hyaena *Crocuta crocuta*.

survey effort), so we grouped data for these villages by location (protected area). This resulted in a total of 11 village samples for this study, with a median of 96 animals per sample (range: 42–1,756). Although larger sample sizes are more likely to un-

cover rare species, we are confident that these sample sizes provide a representative depiction of the catch in each village/protected area (Taylor 2012). Village hunting studies in Gabon (e.g. Starkey 2004, Coad 2007) suggest that hunters have



**Fig. 2.** Camera-trap images showing distinction between Marsh Mongoose *Atilax paludinosus* (above) and Long-nosed Mongoose *Herpestes naso* (below). See main text for a description of distinctive criteria.

good species identification skills, and specific local names for the carnivore species considered herein. However, for Marsh and Long-nosed Mongooses, we cannot be certain that identification was always reliable, especially in the case of 3-day recall surveys and market surveys where animals may have been smoked to preserve the meat. We have therefore grouped records of these two mongooses together, for all hunting and market survey results.

#### *Analysis of small carnivore trade for bushmeat consumption*

To investigate the representation of small carnivores in the commercial trade in Gabon, we used market data collected as part of the 'Projet Gibier', conducted by the Government of Gabon and the University of Stirling (Abernethy *et al.* 2006), which collected data on bushmeat market sales in 11 town and village markets across Gabon during 2000–2006 (Fig. 1). Animals were sold both whole and butchered, and sales were recorded by species and part of the animal. Because small carnivores are very rarely traded as cuts in Gabon, we converted butchered cut sale records into an approximate number of whole animals using the same species weights as for the village offtake dataset. The dataset included a median of 4,387 animals per market (range: 36–35,215), with 105,903 animals recorded in the entire markets dataset (Abernethy *et al.* 2006). As with village hunting offtakes, records of Marsh Mongoose and Long-nosed Mongoose are grouped together.

#### *Statistical analyses*

We calculated the proportion of the village offtake represented by each order, for each of the 11 village samples. From this we then calculated the mean proportion (and associated standard errors) of the catch represented by each order ( $n = 11$  villages). We then repeated this at the species level within Carnivora, to examine the proportion of the village offtake represented by individual carnivore species. We repeated this for the market samples ( $n = 11$  markets).

## Results

#### *Species occurrence and distribution*

We recorded 12 small carnivore species in Gabon and used a total of 1,028 records to map species occurrences across the country (Fig. 3). We obtained the first records of Common Slender Mongoose in Gabon, >350 km outside its range on *The IUCN Red List of Threatened Species* (IUCN 2012) (Fig. 3). We furthermore produced the first definitive records of Cameroon Cusimanse in Gabon, and recorded Egyptian Mongoose *Herpestes ichneumon* about 105 km north of its current *IUCN Red List* range (Fig. 3). Most species are distributed across the country, although Cameroon Cusimanse was recorded only in the north-east and Egyptian Mongoose only in the south (Fig. 3).

#### *Small carnivore offtakes and trade*

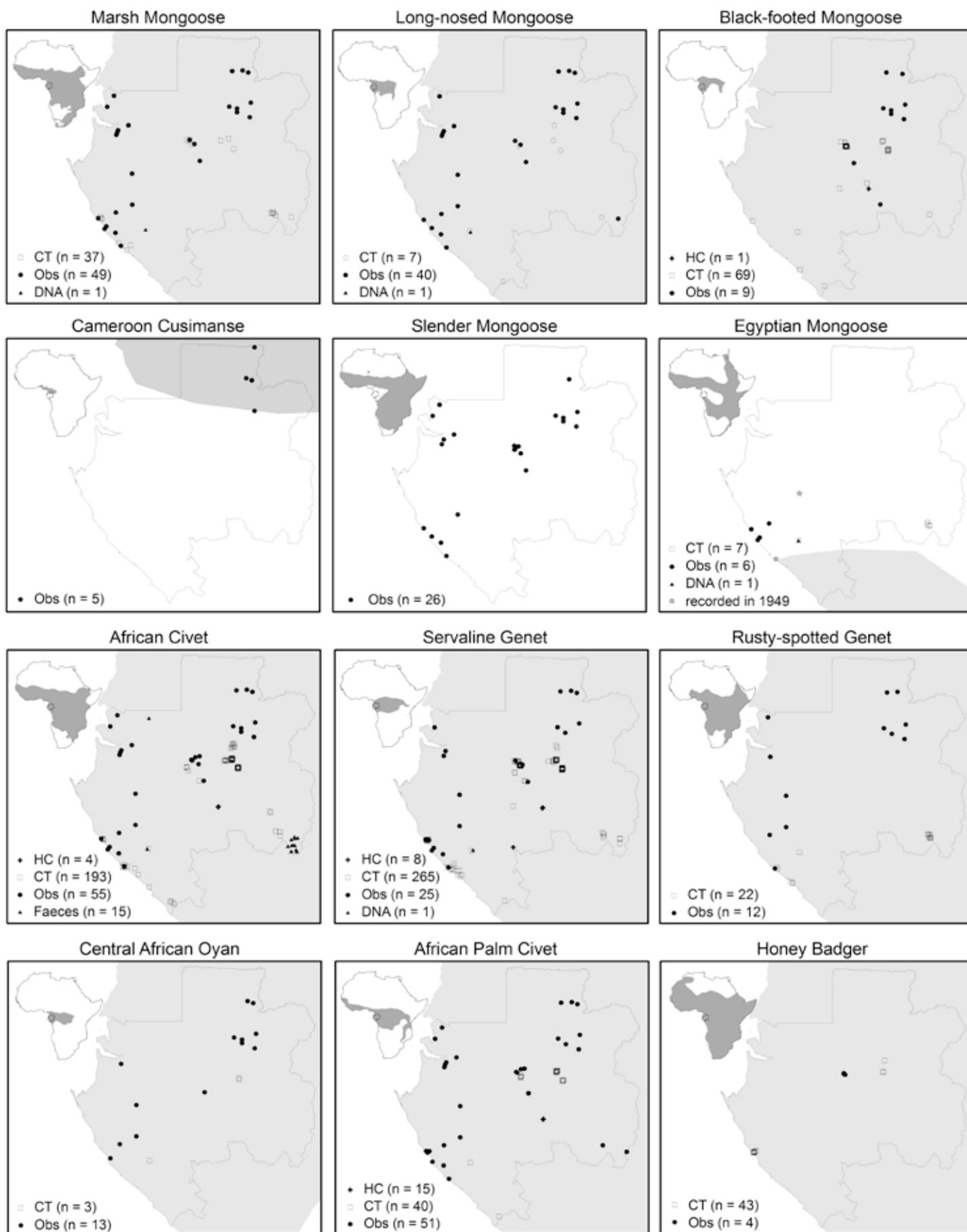
Carnivores comprised 3.4% of village offtakes and 3.1% of all sales in bushmeat markets (Fig. 4). Village offtakes and market sales were both dominated by ungulates, rodents and primates, with all other taxa making up <5% of all hunter catch and sales, respectively (Fig. 4). Among the carnivores recorded, Marsh/Long-nosed Mongoose were the most numerous (group of) species caught in villages (Fig. 5). African Palm Civets *Nandinia binotata* were the second most numerous species in village offtakes and the most numerous species in bushmeat markets, where they were three times more common than any other carnivore species (Fig. 5).

## Discussion

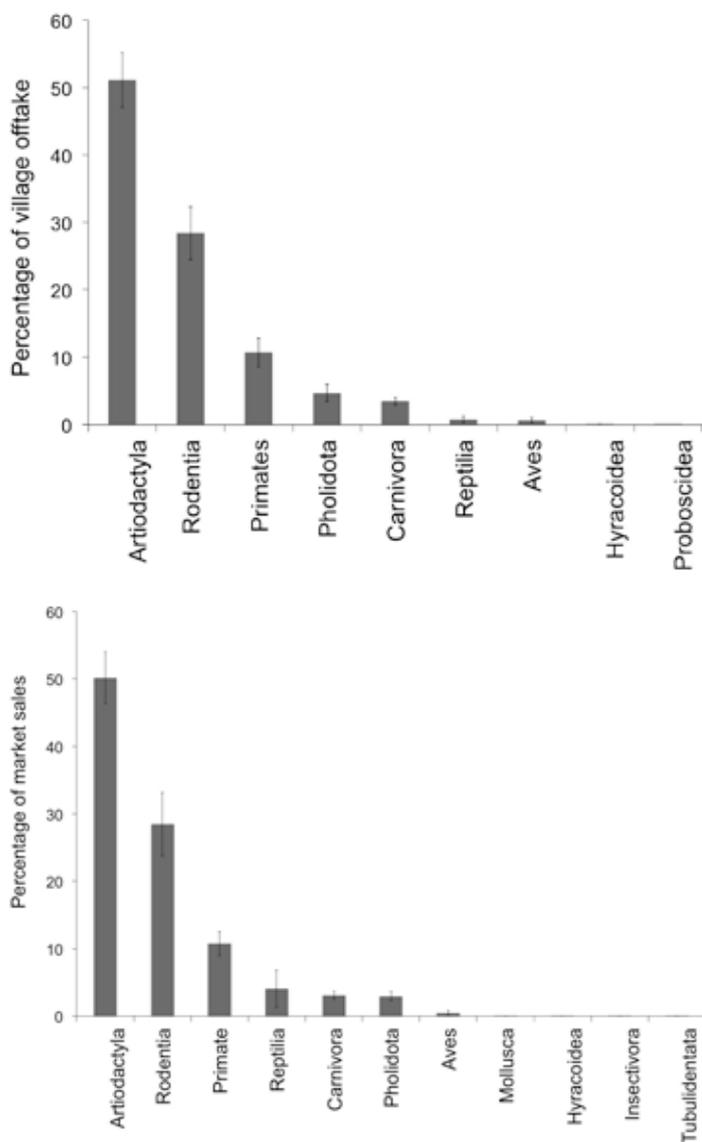
#### *Species extensions of known range*

Malbrant & Maclatchy (1949) speculated that Slender Mongoose might occur in Gabon and neighbouring Congo. However, to date, there had been no confirmed records of the species from the northern bank of the lower Congo River, its presumed western range limit in Central Africa (IUCN 2012). We recorded this species through direct observations at 26 locations, spread across almost the entire country (Fig. 3). While no hard evidence (e.g. photographs or specimens) for the species in Gabon was obtained, observations were made independently by five experienced field biologists (KA, NB, PH, SL and FM). Most records came from a forest–savannah mosaic in northern Lopé NP, where KA, PH and FM made close to 100 independent observations of the species. Observations here were restricted to daytime hours and open savannah habitats, and included multiple observations at close range (<5 m), lasting up to 1 minute. We are therefore confident that our records represent *H. sanguineus*.

The presence of Cameroon Cusimanse in north-east Gabon had been suspected (Hunter & Barrett 2011, IUCN 2012),



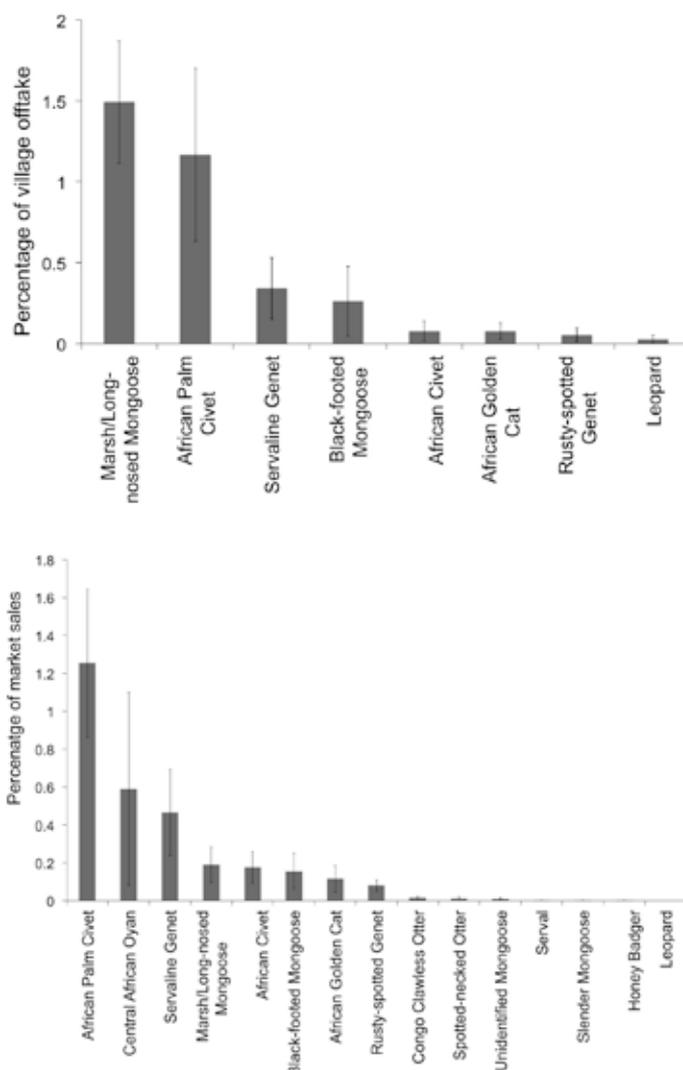
**Fig. 3.** Distribution maps for the small carnivores of Gabon, showing detection points. Grey shading represents generalised range according to *The IUCN Red List of Threatened Species*, both in the Gabon and the inset Africa maps (Data type: HC = hunter catch; CT = camera-trap record; Obs = direct observation; DNA = faecal DNA).



**Fig. 4.** Proportion of carnivores out of all animals (above) harvested in villages and (below) sampled at bushmeat markets during several surveys in Gabon (error bars represent the SE).

but not confirmed anywhere in the country (Goldman 2013). As with Slender Mongoose, we were not able to collect hard evidence for this species's occurrence, but cusimanses were observed directly at five locations by experienced field biologists (PH and SL). Observations included one observation in broad daylight and at close range (<5 m) by PH in September 1998 in what is now Minkébé NP, of a group of four individuals in an open-understorey riparian forest, over about two minutes. Cusimanses are difficult to identify to species in the field, but the location of the observations and suspected range limits of Cameroon Cusimanse (Hunter & Barrett 2011, IUCN 2012), indicate that our observations represent that species.

In Gabon only the south-western tip is currently recognised as within the range of Egyptian Mongoose by IUCN (2012). Our camera-trap records place the species 105 km north of its *IUCN Red List* range, and Malbrant & Maclatchy (1949) listed one record about 100 km further north, near the town of Fougamou (Figs 1, 3). All our records were in or near



**Fig. 5.** Proportion of carnivores out of (above) total catch (number of animals) in villages and (below) total sample (number of animals) at bushmeat markets (error bars represent the SE). Scientific names are given in Table 1, save: African Golden Cat *Profelis aurata*; Leopard *Panthera pardus*; Congo Clawless Otter *Aonyx congicus*; Spotted-necked Otter *Lutra maculicollis*; Serval *Leptailurus serval*

the extensive savannahs in south-east and south-west Gabon (Fig. 1). The record from Fougamou, near the northern tip of the south-western savannahs, aligns well with this pattern. Egyptian Mongoose might thus occur in all extensive savannah areas in southern Gabon.

*Species distribution and habitat preferences*

Marsh Mongoose, Black-footed Mongoose *Bdeogale nigripes*, Long-nosed Mongoose, African Civet *Civettictis civetta*, Servaline Genet and African Palm Civet were recorded throughout Gabon, and across most habitat types. While Rusty-spotted Genet *Genetta maculata* appears to have a country-wide distribution, it was generally recorded in or near savannah areas. Extensive camera-trapping in more pristine, dense forest in the Lopé-Ivindo region yielded no record of the species. Although Rusty-spotted Genet occurs in rainforest, it generally prefers open corridors and secondary growth (Angelici & Gaubert 2013). This habitat preference may explain the lack of

records (and potential absence) from more contiguous primary forests in central Gabon. Conversely, Central African Oyan *Poiana richardsonii* (Fig. 6) was not recorded in the savannah areas. As a canopy species (Van Rompaey & Colyn 2013b), it may have more of an affinity to contiguous forest habitat.

The paucity of Honey Badger *Mellivora capensis* records constrains conclusions on its distribution and habitat preferences in Gabon. It was recorded by camera-traps in just two areas, Ivindo NP in central Gabon and Loango NP near the coast. It was most frequently photo-captured in Loango, where a subset of cameras was placed at subterranean honey nests. There are few direct sightings and bushmeat records of the species in Gabon, and most field surveys and camera-trap studies have failed to record it. While it is known locally by hunters across Gabon, it is generally considered rare (e.g. Mazzocchi 2005). All evidence suggests it occurs patchily and/or at very low densities in Gabon. Both entirely black- and white-mantled morphs of Honey Badger occurred at both sites where they were camera-trapped (Fig. 7). All photographs of pale-mantled individuals portrayed conspicuous white mantles, not the grizzled, greyish ones often seen on this species.

Despite Black-footed Mongoose generally being considered rare (Hunter & Barrett 2011), it was frequently camera-trapped at several sites. In Moukalaba-Doudou, it was photographed more times than any other carnivore species. Direct observations were much less frequent, which may indicate that it is more secretive than other carnivore species. It is thought to be generally absent from disturbed sites (Van Rompaey & Colyn 2013a), but was photo-captured at several actively logged and previously logged sites.

While these observations are based on data collated from many studies, there are gaps in the area coverage and survey intensity is uneven; for example, central Gabon, and areas in and around Lopé and Ivindo National Parks in particular, have been extensively surveyed (see Fig. 1). Our observations on distribution and habitat associations are conservative as a result. Dedicated research effort is required to fill these gaps. Surveys in north-east Gabon could help refine range limits of Cameroon Cusimanse. Likewise, further surveys in the southern forest-savannah landscapes could improve knowledge of



**Fig. 6.** Central African Oyan *Poiana richardsonii* is endemic to Africa's Equatorial rainforest. Owing to its arboreal nature, ground-level camera-traps rarely photograph this species (Photo: L. Bahaa-el-din/Panthera).



**Fig. 7.** Both entirely black (above) and white-mantled morphs (below) of Honey Badger *Mellivora capensis* occurred at each of the two sites where they were camera-trapped (Photos: L. Bahaa-el-din/Panthera).

Egyptian Mongoose range and Rusty-spotted Genet habitat associations.

#### *Hunting pressure on small carnivores in Gabon*

African Palm Civet makes up an important proportion of carnivores found in village offtakes and market sales (Fig. 5). This may result from its relative abundance (estimated to occur at a minimum of about five individuals per km<sup>2</sup> in Gabon; Van Rompaey & Ray 2013), and ease of location through its loud, distinctive call. Coad (2007) found that most small carnivores, excepting Palm Civet, were much more frequently caught than sold to towns. This was certainly the case for Marsh/Long-nosed Mongoose, which was ten times more numerous, proportionally, in hunter catches than in market sales (Fig. 5). Central African Oyan made up a large proportion of market sales (Fig. 5), but this figure was inflated by one particular site: the species was found infrequently in all other markets.

Overall, carnivores do not represent a large proportion of bushmeat sales or village offtakes in Gabon. They may be underrepresented in market surveys, because certain ethnic groups have social restrictions against their consumption. The Bakota of northeast Gabon, for example, have restrictions against eating carnivore meat (Mazzocchi 2005). While traditional restrictions appear to be fading, the consumption of carnivores remains taboo for many ethnic groups, and in par-

ticular for women (Lahm 1993, Starkey 2004, Mazzocchi 2005). While small carnivores may not be targeted for their meat, they may, however, be caught for their skins and body parts, which are used in traditional ceremonies (Lahm 1993). Small carnivores may furthermore be targeted to prevent, or in retribution for, predation on small livestock, mainly poultry (Mazzocchi 2005).

While no in-depth study has focused on the effects of hunting on small carnivore populations in Gabon, Lahm (1993) found in north-east Gabon that a significantly higher richness of small carnivore species occurred in remote areas than near villages where hunting took place. Carnivores were also observed ten times more frequently in remote areas (Lahm 1993). Contrary patterns were observed near the town of Gamba (Fig. 1), where the abundance of small ground-dwelling carnivores (mainly African Civet and unidentified mongooses) was not negatively affected by proximity to settlements, and where higher abundances for those species were associated with proximity to plantations (Vanthomme *et al.* in press). Similarly, studies of trap offtakes in the villages of Dibouka and Kouagna, central Gabon (Coad 2007), show higher catch-per-unit-effort (CPUE) of African Civet and mongooses in plantation areas than in adjacent hunted forests. However, hunters interviewed in these villages (Coad *et al.* 2013) reported that Marsh Mongoose and unidentified genet species had become rare within their hunting territories over their lifetimes, and recounted general declines in hunted species. These three studies highlight that while, overall, small carnivore species richness and the abundance of certain species may be negatively affected by village hunting, some species may adapt more readily to (and even benefit from) land conversion to agriculture. However, differences in relative abundance of carnivores within different habitat types may mask longer-term declines over all habitats due to over-hunting, and care must be taken in the interpretation of these data.

#### Future considerations

Given Gabon's low human population density, its largely intact forest and savannah biomes, and its extensive protected area network, its small carnivore populations are unlikely to be imperilled at this time. However, Gabon is entering a new phase of industrial development, with changes in land use and human disturbance anticipated. In the face of such potential change, national parks are Gabon's first line of defence against biodiversity loss. All 12 small carnivore species known unequivocally from the country inhabit at least one, and up to five, national parks. Species confirmed in only one or two parks may merit recognition in park management plans: Cameroon Cusimanse in Minkébé NP, and Egyptian Mongoose in Loango NP. In addition, changes in habitat may influence the distribution of species across Gabon. Under new development, parks could become increasingly important refuges for species that might depend on contiguous forest or other little-degraded habitat conditions, such as Black-footed Mongoose, Servaline Genet and Central African Oyan. On the other hand, new developments might expand suitable habitat for species favouring anthropogenic conditions, such as African Civet or Rusty-spotted Genet, if hunting is controlled.

Our study represents the first synthesis of collective knowledge about observations of small carnivores in Gabon.

Much is still unknown about these species: continued assimilation of new information, in research studies as well as environmental impact studies, will help manage for viable wildlife populations under future development scenarios.

#### Acknowledgements

Our studies were facilitated by the Gabonese Institute of Research in Tropical Ecology (IRET), its presiding institution CENAREST (Centre National de la Recherche Scientifique et Technologique), and the Gabonese National Parks Agency (ANPN). The studies included in this article were principally funded and supported by Panthera, WCS Gabon, WCS New York, Smithsonian Institution, PPG (Projet Protection des Gorilles) Gabon, The Aspinall Foundation, European Union, Max Planck Institute, Kyoto University, Total, US Fish and Wildlife Service, the Monitoring Illegal Killing of Elephants-CITES programme, USAID CARPE (the US Agency for International Development's Central Africa Regional Program for the Environment), University of Stirling, University of Oxford, University of Cambridge, the National Environmental Research Council (NERC), British Ecological Society (BES), JST/JICA, SATREPS (Science and Technology Research Partnership for Sustainable Development), Shell Gabon, Leibniz Institute for Zoo and Wildlife Research, SAVE Wildlife Conservation Fund, and the National Institute of Communicable Diseases of South Africa.

#### References

- Abernethy, K., Starkey, M., Hymas, O. & Ndong Obiang, A.-M. 2006. *Capacity building for monitoring and managing the bushmeat trade in Gabon. Final report to the Darwin Initiative, Project 162/12/002*. <<http://darwin.defra.gov.uk/>>. Downloaded on 24 April 2013.
- Angelici, F. M. & Gaubert, P. 2013. Large-spotted Genet *Genetta maculata*. Pp. 232–237 in Kingdon, J. & Hoffmann, M. (eds) *Mammals of Africa, V. Carnivores, pangolins, equids and rhinoceroses*. Bloomsbury, London, U.K.
- Baker, C. M. & Ray, J. C. 2013. Marsh Mongoose *Atilax paludinosus*. Pp. 298–302 in Kingdon, J. & Hoffmann, M. (eds) *Mammals of Africa, V. Carnivores, pangolins, equids and rhinoceroses*. Bloomsbury, London, U.K.
- Blake, S., Strindberg, S., Boudjan, P., Makombo, C., Inogwabini B.-I., Ilambu, O., Grossmann, F., Bene-Bene, L., de Semboli, B., Mbenzo, V., S'hwá, D., Bayogo, R., Williamson, L., Fay, M., Hart, J. & Maisels, F. 2007. Forest elephant crisis in the Congo Basin. *PLoS Biology* 5 (4): (e111) 945–953.
- Carpaneto, G. M., Fusari, A. & Okongo, H. 2007. Subsistence hunting and exploitation of mammals in the Haut-Ogooué province, south-eastern Gabon. *Journal of Anthropological Sciences* 85: 183–193.
- Charles-Dominique, P. 1978. Écologie et vie sociale de *Nandinia binotata* (Carnivores, Viverridés): comparaison avec les prosimiens sympatriques du Gabon. *Revue d'Écologie (Terre et Vie)* 32: 477–528.
- [CIA] Central Intelligence Agency 2012. *The world factbook*. <<https://www.cia.gov/library/publications/the-world-factbook/index.html>>. Downloaded on 22 January 2013
- Coad, L. 2007. *Bushmeat hunting in Gabon: socio-economics and hunter behaviour*. University of Cambridge and Imperial College London (Ph.D. thesis), Cambridge and London, U.K.
- Coad, L., Schleicher, J., Milner-Gulland, E. J., Marthews, T. R., Starkey, M., Manica, A., Balmford, A., Mbombe, W., Diop Bineni, T. R. & Abernethy, K. A. 2013. Social and ecological change over a decade in a village hunting system, central Gabon. *Conservation Biology* 27: 270–280.

- Emmons, L. H., Gautier-Hion, A. & Dubost, G. 1983. Community structure of the frugivorous–folivorous forest mammals of Gabon. *Journal of Zoology, London* 199: 209–222.
- Ernst, C., Verhegghen, A., Mayaux, P., Hansen, M. & Defourny, P. 2012. Cartographie du couvert forestier et des changements du couvert forestier en Afrique Centrale. Pp. 23–41 in de Wasseige, C., de Marcken, P., Bayol, N., Hiol Hiol, F., Mayaux, P., Desclée, B., Nasi, R., Billand, A., Defourny, P. & Eba'a Atyi, R. (eds) *Les forêts du Bassin du Congo – état des forêts 2010*. Publications Office of the European Union, Luxembourg.
- Fa, J. E. & Brown, D. 2009. Impacts of hunting on mammals in African tropical moist forests: a review and synthesis. *Mammal Review* 39: 231–264.
- Gaubert, P., Papes, M. & Peterson, A. T. 2006. Natural history collections and the conservation of poorly known taxa: ecological niche modeling in central African rainforest genets (*Genetta* spp.). *Biological Conservation* 130: 106–117.
- Goldman, C. A. 2013. Cameroon Cusimanse *Crossarchus platycephalus*. Pp. 382–383 in Kingdon, J. & Hoffmann, M. (eds) *Mammals of Africa, V. Carnivores, pangolins, equids and rhinoceroses*. Bloomsbury, London, U.K.
- Henschel, P., Hunter, L. T. B., Coad, L., Abernethy, K. A. & Mühlenberg, M. 2011. Leopard prey choice in the Congo Basin rainforest suggests exploitative competition with human bushmeat hunters. *Journal of Zoology, London* 285: 11–20.
- Hoffmann, M. & Taylor, M. E. 2013. Slender Mongoose *Herpestes sanguineus*. Pp. 314–318 in Kingdon, J. & Hoffmann, M. (eds) *Mammals of Africa, V. Carnivores, pangolins, equids and rhinoceroses*. Bloomsbury, London, U.K.
- Hunter, L. & Barrett, P. 2011. *A field guide to the carnivores of the world*. Princeton University Press, Princeton, U.S.A.
- IUCN 2012. *IUCN Red List of Threatened Species*. Version 2012.2. <www.iucnredlist.org>. Downloaded on 17 October 2012.
- Jones, K. E., Bielby, J., Cardillo, M., Fritz, S. A., O'Dell, J., Orme, C. D. L., Safi, K., Sechrest, W., Boakes, E. H., Carbone, C., Connolly, C., Cutts, M. J., Foster, J. K., Grenyer, R., Habib, M., Plaster, C. A., Price, S. A., Rigby, E. A., Rist, J., Teacher, A., Bininda-Emonds, O. R. P., Gittleman, J. L., Mace, G. M., Purvis, A. & Michener, W. K. 2009. PanTHERIA: a species-level database of life history, ecology, and geography of extant and recently extinct mammals. *Ecology* 90: 2648–2648.
- Kingdon, J. 1997. *The Kingdon field guide to African mammals*. A. & C. Black, London, U.K.
- Lahm, S. A. 1993. *Ecology and economics of human/wildlife interaction in northeastern Gabon*. New York University (Reports of the Department of Anthropology 151), New York, U.S.A.
- Lahm, S. A. 2001. Hunting and wildlife in northeastern Gabon: why conservation should extend beyond protected areas. Pp. 344–354 in Weber, W., White, L., Vedder, A. & Naughton-Treves, L. (eds) *African rain forest ecology and conservation – an interdisciplinary perspective*. Yale University Press, New Haven, U.S.A.
- Malbrant, R. & Maclatchy, A. 1949. *Faune de l'Équateur africain français, Tome II, mammifères*. Paul Lechevalier, Paris, France.
- Mazzocchetti, F. 2005. *Utilisations et représentations de la faune sauvage (tchetée) chez les Bakota de la région de Makokou (Gabon)*. Université d'Orléans (M.Phil. thesis), Orléans, France.
- Ray, J. C. 1997. Comparative ecology of two African forest mongooses, *Herpestes naso* and *Atilax paludinosus*. *African Journal of Ecology* 35: 237–253.
- Ray, J. C. 2001. Carnivore biogeography and conservation in the African forest: a community perspective. Pp. 214–232 in Weber, W., White, L., Vedder, A. & Naughton-Treves, L. (eds) *African rain forest ecology and conservation – an interdisciplinary perspective*. Yale University Press, New Haven, U.S.A.
- Starkey, M. 2004. *Commerce and subsistence: the hunting, sale and consumption of bushmeat in Gabon*. University of Cambridge (Ph.D. thesis), Cambridge, U.K.
- Taylor, G. 2012. *A systematic review of the bushmeat trade in West and Central Africa*. University of Oxford (M.Sc. thesis), Oxford, U.K.
- Van Rompaey, H. & Colyn, M. 2013a. Black-legged Mongoose *Bdeogale nigripes*. Pp. 326–328 in Kingdon, J. & Hoffmann, M. (eds) *Mammals of Africa, V. Carnivores, pangolins, equids and rhinoceroses*. Bloomsbury, London, U.K.
- Van Rompaey, H. & Colyn, M. 2013b. Central African Linsang *Poiana richardsonii*. Pp. 253–254 in Kingdon, J. & Hoffmann, M. (eds) *Mammals of Africa, V. Carnivores, pangolins, equids and rhinoceroses*. Bloomsbury, London, U.K.
- Van Rompaey, H. & Colyn, M. 2013c. Long-nosed Mongoose *Xenogale naso*. Pp. 295–298 in Kingdon, J. & Hoffmann, M. (eds) *Mammals of Africa, V. Carnivores, pangolins, equids and rhinoceroses*. Bloomsbury, London, U.K.
- Van Rompaey, H. & Colyn, M. 2013d. Crested Genet *Genetta cristata*. Pp. 222–224 in Kingdon, J. & Hoffmann, M. (eds) *Mammals of Africa, V. Carnivores, pangolins, equids and rhinoceroses*. Bloomsbury, London, U.K.
- Van Rompaey, H. & Ray, J. C. 2013. African Palm Civet *Nandinia binotata*. Pp. 139–143 in Kingdon, J. & Hoffmann, M. (eds) *Mammals of Africa, V. Carnivores, pangolins, equids and rhinoceroses*. Bloomsbury, London, U.K.
- Vanthomme, H., Kolowski, J., Korte, L. & Alonso, A. in press. Distribution of a community of mammals in relation to roads and other human disturbances in Gabon, Central Africa. *Conservation Biology*.
- Veron, G. & Heard, S. 2000. Molecular systematics of the Asiatic Viverridae (Carnivora) inferred from mitochondrial cytochrome b sequence analysis. *Journal of Zoological Systematics and Evolutionary Research* 38: 209–217.
- Walsh, P. D., Abernethy, K. A., Bermejo, M., Beyers, R., De Wachter, P., Ella Akou, M., Huijbregts, B., Idiata Mambounga, D., Kamdem Toham, A., Kilbourn, A. M., Lahm, S. A., Latour, S., Maisels, F., Mbina, C., Mihindou, Y., Ndong Obiang, S., Ntsame Effa, E., Starkey, M. P., Telfer, P., Thibault, M., Tutin, C. E. G., White, L. J. T. & Wilkie, D. S. 2003. Catastrophic ape decline in western equatorial Africa. *Nature* 422: 611–614.
- Wilkie, D. S., Morelli, G. A., Demmer, J., Starkey, M., Telfer, P. & Steil, M. 2006. Parks and people: assessing the human welfare effects of establishing protected areas for biodiversity conservation. *Conservation Biology* 20: 247–249.

**<sup>1</sup>Panthera, 8 West 40th Street, 18th Fl, NY, NY 10018, U.S.A.**

**E-mail: laila.sp@gmail.com**

**<sup>2</sup>Wildlife Conservation Research Unit (WildCRU), Department of Zoology, Oxford University, Tubney, Abingdon Road, OX13 5QL, U.K.**

**<sup>3</sup>School of Life Sciences, University of Kwazulu-Natal, Westville Campus, Private Bag X54001, Durban, 4000, South Africa.**

**<sup>4</sup>Wildlife Conservation Society, 2300 Southern Blvd., Bronx, NY 10460, U.S.A.**

<sup>5</sup>School of Natural Sciences, University of Stirling, Stirling  
FK9 4LA, U.K.

<sup>6</sup>Institut de Recherche en Ecologie Tropicale, CENAREST,  
BP 13354, Libreville, Gabon.

<sup>7</sup>Leibniz Institute for Zoo and Wildlife Research,  
Alfred-Kowalke-Str. 17, 10315 Berlin, Germany.

<sup>8</sup>The Aspinall Foundation, BP 583, Franceville, Gabon.

<sup>9</sup>Environmental Change Institute, University of Oxford,  
4 South Parks Road, Oxford, OX1 3PY, U.K.

<sup>10</sup>Max Planck Institute for Evolutionary Anthropology,  
Deutscher Platz 6, 04103 Leipzig,  
Germany.

<sup>11</sup>Graduate School of Science, Kyoto University,  
Kitashirakawa Oiwake-cho, Sakyo-ku, Kyoto City, Kyoto,  
606-8502, Japan.

<sup>12</sup>Institut de Recherche en Ecologie Tropicale, B.P. 180,  
Makokou, Gabon.

<sup>13</sup>Center for Conservation Education and Sustainability,  
Smithsonian Conservation Biology Institute, National  
Zoological Park, P.O. Box 37012, MRC 0705, Washington  
D.C. 200013-7012, U.S.A.

\*These authors contributed equally to the preparation of  
the manuscript.