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Yellow Mongoose *Cynictis penicillata* (Photo: E. Do Linh San)

ZSSA
Zoological Society of Southern Africa

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Editorial

African small carnivores: the 'forgotten Eden'

The overarching aim of *Small Carnivore Conservation* (*SCC*) is to improve the conservation outlook for the world's small carnivores through enhancing the availability and dissemination of relevant information, and stimulating further conservation work. Small carnivores are defined for the journal as those species under the mandate of the IUCN SSC Small Carnivore Specialist Group. In 2014, *SCC* will celebrate its 25th anniversary. There is no doubt that, over the past 24 years, this newsletter and then journal has contributed tremendously to the above-mentioned goal. However, a closer look at the geographic range of species covered by papers in *SCC*, quickly shows the paucity of articles dealing with American (especially South American) and African species. This is particularly true of the articles published in the past decade, with a large bias towards contributions covering tropical Asian species.

One recent step towards alleviating this bias in geographic range coverage was for the *SCC* Editorial Board to instigate a Special Issue focussing on the Americas. This volume was published in 2009, just before the 10th International Mammalogical Congress in Mendoza, Argentina. Quite logically, it was decided that this effort would be followed by a collation of papers focussing on African small carnivores. Four years later, and once again just a few weeks prior to an International Mammalogical Congress (the 11th, in Belfast, Northern Ireland), we are most delighted to be able to present you this 'Special Africa Issue'.

This team effort was kick-started by the input of Mike Hofmann, who greatly assisted us through suggesting several possible contributors. The call for contributions was made in January 2012, and the last manuscript was received in April 2013. We must here sincerely thank all the authors for their exciting contributions and – at times herculean – efforts to amend and ameliorate consecutive drafts. To us, they are true modern heroes who dedicate their time and energy to a better knowledge of mammals, in this case small carnivores, and their conservation. We are also greatly indebted to all the reviewers for their precious comments, to Will 'Hawkeye' Duckworth for his tireless efforts to improve the quality of manuscripts, as well as to Divya Mudappa for her expert technical assistance and endless patience. Finally, we gratefully acknowledge our generous sponsors, without whom the publication of this Special Issue would not have been possible: the Southern African Wildlife Management Association (Louw Hoffmann, Elma Marais and SAWMA Council Members), the Zoological Society of Southern Africa (Sarita Maree and ZSSA Council Members), as well as the Govan Mbeki Research and Development Centre (Gideon de Wet), at the University of Fort Hare, South Africa.

This issue opens with an overview paper on the conservation status, distribution and species richness of African small carnivores. We hope that this contribution will give readers a quick and objective evaluation of 'what is fine', 'what is not', and 'what needs to be done' in terms of small carnivore research and conservation in Africa. The bulk of this volume is then made of solid contributions reporting the results of faunal surveys involving small carnivores (in three cases as main focus, and in three cases as part of broader mammal surveys) in a number of African countries, namely Liberia, Gabon, Tanzania and Zambia. One of these articles contains the first picture of a live Bourlon's Genet, whereas another paper describes extensions of known range for two small carnivore species. Several shorter articles report exciting findings, such as the presence of Johnston's Genet in Senegal and that of a polecat-like mustelid in Algeria, the probable 'rediscovery' of Pousargues's Mongoose in Central African Republic, as well as the first record of a chinchilla phenotype in Viverridae.

Besides observation-based papers, and a few questionnaire and bushmeat surveys, most data presented in this Special Issue, as is typical in recent volumes of *SCC*, are based on camera-trapping. This booming technique allows determination or confirmation of the distribution of species, as clearly showcased for several in this issue. In addition, with the introduction of camera-traps into the ecologist's arsenal of equipment, general knowledge of small, elusive, often nocturnal, small carnivores has clearly begun to increase. However, although this method allows some insights into the habitat ecology and broad activity patterns of small carnivores, relatively little information can be obtained on other aspects of the ecology and behaviour of species for which individual identification is difficult (let alone impossible). In such cases radio-tracking allows the determination of basic information such as activity rhythms, resting-site ecology, home-range size, movement patterns (including dispersal) and, ultimately, a species's socio-spatial organisation. Yet, such studies are rarely undertaken and often involve a few tagged individuals only (see Ayalew *et al.*, this volume). Radio-tracking studies cannot claim to be impeded by cost, because the deployment of dozens or hundreds of camera-traps is comparatively expensive. Instead, working for long hours in often difficult terrain, under unfavourable climatic conditions, sometimes among dangerous animals, and over several months or even years might constitute and sadly remain some of the most challenging factors limiting current and future knowledge of small carnivores.

In comparison with large carnivores, including Lion, Leopard, Cheetah or Spotted Hyaena, African small carnivores have received very little attention; hence, to us, these fascinating creatures constitute nothing else than a 'forgotten Eden'. We sincerely hope that the exciting findings published in this Special Issue will stimulate some of our expert readers and colleagues to submit their own data on African small carnivores to *SCC*, even if this information was obtained as a 'by-product' of other studies. The important role of small carnivores in ecosystems and the severe lack of data on most species, as highlighted in this volume, will hopefully also lead to the initiation of more research aiming at describing the general biology, ecology and behaviour of little-known African small carnivores.

Lastly, we would like to dedicate this 'Special Africa Issue' to the late Harry Van Rompaey, founder and first Editor-in-Chief of *SCC*, and a great 'connaisseur' of African small carnivores!

Emmanuel DO LINH SAN
Michael J. SOMERS
(Guest Editors)

Éditorial

Petits carnivores africains: l''Éden oublié'

L'objectif prioritaire de *Small Carnivore Conservation* (*SCC*) est d'améliorer les perspectives de conservation pour les petits carnivores du monde en augmentant la disponibilité et la diffusion des informations pertinentes et de stimuler la poursuite des travaux de conservation. Les petits carnivores sont définis pour le journal comme des espèces sous mandat du Groupe des Spécialistes des Petits Carnivores (SCSG) de la Commission de Survie des Espèces (SSC) de l'Union Internationale pour la Conservation de la Nature (IUCN). En 2014, *SCC* fêtera son 25e anniversaire. Il ne fait aucun doute qu'au cours des 24 dernières années, ce bulletin, puis journal, a énormément contribué aux objectifs mentionnés ci-dessus. Cependant, un examen plus attentif de la répartition géographique des espèces couvertes par les articles parus dans *SCC* montre rapidement la rareté des articles traitant des espèces américaines (spécialement d'Amérique du Sud) et africaines. Cela est particulièrement vrai des articles publiés dans la dernière décennie, avec un biais en faveur des contributions couvrant les espèces de l'Asie tropicale.

Une étape récente vers la réduction de cette partialité dans la couverture géographique des espèces de petits carnivores a été pour le comité de rédaction de *SCC* de lancer la préparation d'un numéro spécial mettant l'accent sur les Amériques. Ce volume a été publié en 2009, juste avant le 10e Congrès International de Mammalogie à Mendoza, en Argentine. Assez logiquement, il a été décidé que cet effort serait suivi d'une mise en commun de documents axés sur les petits carnivores africains. Quatre ans plus tard, et une fois de plus quelques semaines avant un Congrès International de Mammalogie (le 11e, à Belfast, en Irlande du Nord), nous sommes très heureux de pouvoir vous présenter ce « Numéro Spécial Afrique ».

Ce travail d'équipe a bénéficié du « coup d'envoi » de Mike Hofmann, qui nous a beaucoup aidés en suggérant plusieurs contributeurs possibles. L'appel à contributions a été fait en janvier 2012, et le dernier manuscrit a été reçu en avril 2013. Nous devons ici remercier sincèrement tous les auteurs pour leurs contributions passionnantes et leurs efforts – parfois herculéens – pour modifier et améliorer les versions consécutives de leurs manuscrits. Pour nous, ils sont de véritables héros des temps modernes qui consacrent leur temps et leur énergie à une meilleure connaissance des mammifères, en l'occurrence les petits carnivores, et leur conservation. Nous sommes également très reconnaissants à tous les relecteurs pour leurs commentaires précieux, à Will « Hawkeye » Duckworth pour ses efforts inlassables pour améliorer la qualité des manuscrits, ainsi qu'à Divya Mudappa pour son assistance technique experte et sa patience infinie. Enfin, nous sommes reconnaissants à nos généreux sponsors, sans qui la publication de ce numéro spécial n'aurait pas été possible: la Southern African Wildlife Management Association (Louw Hoffmann, Elma Marais et les membres du Conseil de la SAWMA), la Zoological Society of Southern Africa (Sarita Maree et les membres du Conseil de la ZSSA), ainsi que le Govan Mbeki Research and Development Centre (Gideon de Wet), à l'Université de Fort Hare, en Afrique du Sud.

Ce numéro débute par un document de synthèse sur l'état de conservation, la distribution et la richesse des espèces de petits carnivores africains. Nous espérons que cette contribution fournira aux lecteurs une évaluation rapide et objective de « ce qui est bien », « ce qui ne l'est pas », et « ce qui doit être fait » en termes de recherche et de conservation des petits carnivores en Afrique. La majeure partie de ce volume est ensuite faite de contributions solides qui rapportent les résultats d'enquêtes faunistiques impliquant des petits carnivores (dans trois cas en tant que sujets d'étude principaux, et dans trois cas dans le cadre d'enquêtes générales sur les mammifères) dans un certain nombre de pays africains, à savoir le Libéria, le Gabon, la Tanzanie et la Zambie. L'un de ces articles contient la première photographie d'un individu vivant de la Genette de Bourlon, tandis qu'un autre document décrit l'extension de l'aire de distribution connue pour deux espèces de petits carnivores. Plusieurs articles plus courts rapportent des résultats intéressants, tels que la présence de la Genette de Johnston au Sénégal et celle d'un mustélidé de « type putois » en Algérie, la probable « redécouverte » de la Mangouste des savanes en République centrafricaine, ainsi que la première mention d'un phénotype chinchilla chez les Viverridae.

Outre les articles basés sur l'observation, ainsi que quelques enquêtes par questionnaires et liées à la consommation et au commerce de la viande de brousse, la plupart des données présentées dans ce numéro spécial ont été récoltées par l'entremise du piégeage photographique, tendance qui transparaît également dans les derniers volumes de *SCC*. Cette technique en plein essor permet la détermination ou la confirmation de la répartition géographique des espèces, tel que c'est le cas pour plusieurs d'entre elles dans ce volume. En outre, avec l'introduction des pièges photographiques dans l'arsenal d'équipement de l'écologiste, les connaissances générales sur des carnivores de petite taille, furtifs et souvent nocturnes, ont clairement commencé à augmenter. Cependant, bien que cette méthode permette d'obtenir un aperçu sur l'écologie de l'habitat et le patron général d'activité des petits carnivores, relativement peu d'informations peuvent être obtenues sur d'autres aspects de l'écologie et du comportement des espèces pour lesquelles l'identification individuelle est difficile, voire impossible. Dans ce cas, le radio-pistage permet de déterminer des informations de base telles que les rythmes d'activité, l'écologie des sites de repos, la taille du domaine vital, les modes de déplacement (y compris la dispersion) et, en fin de compte, l'organisation socio-spatiale d'une espèce. Pourtant, de telles études sont rarement effectuées et comportent souvent seulement quelques individus marqués (voir Ayalew *et al.* dans ce volume). Les études par radio-pistage ne peuvent pas prétendre être entravées par le coût, puisque que le déploiement de dizaines ou de centaines de pièges photographiques est comparativement cher. Au lieu de cela, le fait de devoir travailler pendant de longues heures dans des terrains souvent difficiles, dans des conditions climatiques défavorables, parfois parmi des animaux dangereux, et pendant plusieurs mois, voire plusieurs années, pourrait constituer et malheureusement demeurer l'aspect majeur limitant les connaissances actuelles et futures sur les petits carnivores.

En comparaison avec les grands carnivores, y compris le Lion, le Léopard, le Guépard ou l'Hyène tachetée, les petits carnivores africains ont reçu très peu d'attention. Ainsi, pour nous, ces créatures fascinantes constituent ni plus ni moins qu'un « Éden oublié ». Nous espérons sincèrement que les résultats passionnants publiés dans ce numéro spécial stimuleront certains de nos lecteurs experts et des collègues à soumettre leurs propres données sur les petits carnivores africains à *SCC*, même si cette information a été obtenue en tant que « sous-produit » d'autres études. Nous souhaitons aussi que le rôle important des petits carnivores dans les écosystèmes et le grave manque de données sur la plupart des espèces, tel que mis en évidence dans ce volume, encourageront plus de recherche visant à décrire la biologie générale, l'écologie et le comportement de petits carnivores africains peu connus.

Enfin, nous tenons à dédier ce « Numéro Spécial Afrique » à feu Harry Van Rompaey, fondateur et premier rédacteur en chef de *SCC*, et un grand connaisseur des petits carnivores africains!

Emmanuel DO LINH SAN
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(Rédacteurs invités)

Conservation status, distribution and species richness of small carnivores in Africa

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Abstract

We assessed the global conservation status of small carnivores in Africa based on the *IUCN Red List of Threatened Species*. African small carnivores represent about 34% of extant small carnivores worldwide. Familial diversity is intermediate, with four of the world's nine families represented (Herpestidae: 47% of African species; Mustelidae: 20%; Nandiniidae: 2%; and Viverridae: 31%). Greatest species richness is recorded in equatorial Africa, although most sub-Saharan countries host at least 15 species (with a maximum of 26 in any one country). Of the 55 small carnivore species found in Africa, 51 (93%) are predominantly distributed in Africa and 48 (87%) are endemic. In terms of *IUCN Red List* conservation status, 43 species are Least Concern (LC), three are Near Threatened (NT), four are Vulnerable (VU) and five are Data Deficient (DD). No African small carnivore species is currently listed as Endangered (EN), Critically Endangered (CR), Extinct in the Wild (EW) or Extinct (EX). For data-sufficient small carnivore species (i.e. non-DD), 8% were considered threatened (all VU), primarily a result of population declines and small distribution ranges (encompassing only 2–6 countries). The exact percentage of threatened species is unknown, but is between 7% (if no DD species is threatened) and 16% (if all are). Population trends are adjudged unknown for 46% of the species, while 27% are thought stable and 27% are believed decreasing. Compared with mammals worldwide, the overall conservation status of small carnivores in Africa appears relatively favourable. However, declining populations of many species and existing (habitat loss, degradation and fragmentation; exploitation for meat) and new threats (rapid economic development expanding the wild meat market, possibly to Asia) hint that additional small carnivore species may become threatened unless effective conservation strategies are implemented. This is of prime importance considering that over a quarter of the world's small carnivore species are endemic to Africa. Actions to remove or mitigate factors threatening Vulnerable and Near Threatened species constitute the short-term priority for small carnivore conservation in Africa.

Keywords: conservation status, Data Deficient, Herpestidae, *IUCN Red List*, Least Concern, Mustelidae, Nandiniidae, Near Threatened, population trends, species richness, Viverridae, Vulnerable

Statut de conservation, répartition et richesse spécifique des petits carnivores en Afrique

Résumé

Nous avons évalué l'état de conservation global des petits carnivores en Afrique en utilisant la *Liste Rouge des Espèces Menacées de l'UICN*. Les petits carnivores africains représentent environ 34% des petits carnivores existant à travers le monde. La diversité familiale est intermédiaire, avec quatre des neufs familles de la planète représentées (Herpestidae: 47% des espèces africaines; Mustelidae: 20%; Nandiniidae: 2%, et Viverridae: 31%). La plus grande richesse en espèces est enregistrée en Afrique équatoriale, bien que la plupart des pays d'Afrique subsaharienne hébergent au moins 15 espèces (avec un maximum de 26 dans un même pays). Sur les 55 espèces de petits carnivores qui se trouvent sur le continent africain, 51 (93%) sont essentiellement distribuées en Afrique et 48 (87%) sont endémiques. En ce qui concerne leurs statuts de conservation sur la *Liste Rouge de l'UICN*, 43 espèces sont dans la catégorie « Préoccupation mineure » (LC), trois sont « Quasi menacé » (NT), quatre sont « Vulnérable » (VU) et cinq sont classées dans la catégorie « Données insuffisantes » (DD). Aucune espèce de petits carnivore n'est actuellement considérée « En danger » (EN), « En danger critique » (CR), « Éteint à l'état sauvage » (EW) ou « Éteint » (EX). Parmi les espèces de petits carnivores pour lesquelles il existe des données suffisantes afin de leur attribuer un statut, 8% ont été considérées comme menacées (toutes VU), principalement en raison du déclin des populations concernées et de leurs aires de répartition géographique réduites (incluant seulement de 2–6 pays). Le pourcentage exact d'espèces menacées est inconnu, mais il est compris entre 7% (si aucune espèce DD n'est menacée) et 16% (si toutes le sont). Les tendances démographiques sont adjugées inconnues pour 46% des espèces, tandis que 27% sont considérées stables et 27% sont estimées être en baisse. Par rapport aux mammifères à travers le monde, le statut général de conservation des petits carnivores en Afrique semble relativement favorable. Toutefois, le déclin des populations de nombreuses espèces et les menaces existantes (perte, dégradation et fragmentation de l'habitat; exploitation pour la viande) et les nouvelles menaces (développement économique rapide entraînant une expansion du marché de la viande sauvage, peut-être jusqu'en Asie) laissent entendre que d'autres espèces de petits carnivores pourraient devenir menacées à moins que des stratégies de conservation efficaces soient mises en œuvre. Ceci est d'une importance primordiale étant donné que plus d'un quart des espèces de petits carnivores du monde sont endémiques à l'Afrique. Des actions pour éliminer ou atténuer les facteurs menaçant les espèces « Vulnérable » et « Quasi menacé » constituent la priorité à court terme pour la conservation des petits carnivores en Afrique.

Mots clés: « Données insuffisantes », Herpestidae, *Liste Rouge de l'UICN*, Mustelidae, Nandiniidae, « Préoccupation mineure », « Quasi menacé », richesse spécifique, statut de conservation, tendances démographiques, Viverridae, « Vulnérable »

Introduction

Encompassing nearly 30.3 million km^2 or 20% of the Earth's land surface, Africa represents the second largest continent and one of the oldest and most geologically stable land masses on Earth, existing in continental form for at least 3,800 million years of Earth's history (Schlüter 2008). Spanning the Equator, Africa is the only continent to occupy both northern and southern temperate zones (O'Brien & Peters 1999). Latitude ranges from 37°20′N in Tunisia to 34°50′S along South Africa's Cape region, longitude of the mainland from 17°31′W in Dakar, Senegal, to 51°25′E in coastal Somalia. With the exception of the Atlas Mountains, running from southwestern Morocco along the Mediterranean coastline to the eastern edge of Tunisia, northern Africa is dominated by the world's largest desert: the Sahara Desert covers approximately 9 million km^2, nearly 30% of continental Africa. In the east, the Great Rift Valley, a massive depression bordered by numerous mountain chains, runs from northern Syria to central Mozambique. The world's longest river, the Nile, flows northward through the Sahara, intersecting 10 African countries and running over 6,695 km from its origin in Rwanda (Liu *et al.* 2009) to its mouth along Egypt's Mediterranean coastline (Reader 1997). The Sahel, a broad expanse of semi-arid grasslands spanning the southern edge of the Sahara Desert, separates the dry deserts of North Africa from the tropical Sudanian Savannah of north-central Africa. Bordering the eastern limits of the Sahel are the Ethiopian Highlands, a contiguous region where altitude rarely falls below 1,500 m. Two major rivers, the Niger in the west and the Congo in Central Africa, help to shape the tropical forests of west-central Africa. Spanning more than 4,000 km, the Congo forms the second largest river basin in the world, covering nearly 3.7 million km^2 across seven countries (Reader 1997). South of the Central African rainforests lie the miombo woodlands, a broad belt of wooded savannah running west from Angola into eastern Tanzania (Le Houérou 2009). The Southern African Subregion, south of the Kunene and Zambezi Rivers, is dominated by the Kalahari and Namib Deserts which cover most of Botswana (excepting the Okavango Delta and northern miombo woodlands) and Namibia. Additional ecoregions include the Karoo of South Africa; the bushveld of eastern Botswana, South Africa and Zimbabwe; and the Zambezian and mopane woodlands of southeast Africa. These diverse ecoregions, delimited by distinct bioclimatic parameters such as soil types, climate and vegetation (Le Houérou 2009), combined with historical geomorphological changes, climatic oscillations, colonisation patterns and *in situ* evolution have all helped shape Africa's modern mammal community (Sanders & Werdelin 2010). Supporting 1,161 mammal species in 16 orders (Kingdon *et al*. 2013), nearly a quarter of all living mammals, Africa is second only to the Neotropics (with 1,282 species) in overall mammal species richness (Mace *et al.* 2005). However, local African mammal communities tend to hold more species than their Neotropical counterparts, despite similarities in area, latitudinal position, landscapes and regional species pools (Vivo & Carmignotto 2004, Nieto *et al*. 2005), often attributable to differences in abundance of medium to large species (Cristoffer & Peres 2003, Vivo & Carmignotto 2004, Nieto *et al*. 2005). Unfortunately, Africa's mammalian communities currently face extreme threats from one species in particular, *Homo sapiens*. Approximately 15% (1.05 US billion) of the estimated global human population (6.97 US billion) live in Africa (UN 2011). People exert local, regional and national pressure on wildlife populations, especially mammals of medium to large size (i.e. >3 kg; Cardillo *et al.* 2005), often enhancing their risk of extinction.

Because of their size, often diurnal habits and economic value (e.g. food and tourism, including hunting), many large African mammals have been subjected to considerable fundamental (see Kingdon *et al.* 2013) and applied research, primarily serving the purposes of the wildlife industry (see Bothma & du Toit 2010). Among those species, large African carnivores have drawn considerable attention from researchers (and conservation organisations), initially through their charisma but also for their potential for conflicts and the resulting threats to several species and populations (Gittleman *et al.* 2001). Large carnivores are important in regulating land and aquatic ecosystems (Estes *et al.* 2011) through cascading interactions across trophic levels (Steneck 2005, Terborgh & Estes 2010). Small carnivores, on the other hand, although more species-rich and generally more common, are mistakenly thought to have a lower impact at the ecosystem level (Roemer *et al.* 2009). Indeed, although their impacts are not on the same guild of prey as large carnivores, small carnivores are similarly important ecosystem regulators through structuring small mammal and/or invertebrate communities (Virgós *et al.* 1999), which in turn might affect higher trophic levels. They may also be important in seed dispersal, affecting plant gene flow or ecology (Herrera 1989, Jordano *et al*. 2007, Nakashima & Sukor 2009, Mudappa *et al*. 2010). Possible roles of small carnivores in shaping ecosystems have also been shown accidently through introductions. For example, American Minks *Neovison vison* introduced to Europe can cause a shift in bird breeding sites (Nordström & Korpimäki 2004) and compete with local species (Harrington & Macdonald 2008). There are similar examples of important ecological impacts from introduced species in several families of land Carnivora that contain small to mid-sized species (Roemer *et al.* 2009). Finally, where larger carnivores are exterminated by humans (directly or through habitat change), small carnivores have or may become *de facto* apex predators in these ecosystems (Crooks & Soulé 1999, Roemer *et al.* 2009), potentially altering their ecological roles and importance in such systems.

In Africa, only some of the diurnal, social small carnivore species, specifically Meerkat *Suricata suricatta* (see back cover), Banded Mongoose *Mungos mungo*, Common Dwarf Mongoose *Helogale parvula* and Yellow Mongoose *Cynictis penicillata* (see cover), have been extensively studied. All others, including the widely distributed Common Slender Mongoose *Herpestes sanguineus* (Fig. 1), have received limited attention. Hence, with few exceptions, the behaviour and ecology, and therefore the ecological role, of most African small carnivore species remain unknown. The conservation status of all mammals worldwide was assessed for the 2008 *IUCN Red List of Threatened Species* (Schipper *et al.* 2008b) and results were summarised for small carnivores globally (Schipper *et al.* 2008a) as well as in the Americas (Belant *et al.* 2009). Here, we report on the conservation status, distribution and species richness of small carnivores (Herpestidae, Mustelidae, Nandiniidae and Viverridae) in Africa.

Fig. 1. Common Slender Mongoose *Herpestes sanguineus* (here two juveniles in Kruger National Park, South Africa) is one of the most widespread and commonly seen mongooses in Africa. Yet, little is known about its behavioural ecology (Photo: E. Do Linh San).

Methods

Methods to assess the conservation status of the world's mammals through the Global Mammal Assessment in 2008 were reported by Schipper *et al.* (2008a, 2008b). Contrary to previous mammal *IUCN Red List* assessments, that in 2008 used an expert review process. General information was gathered on distribution, population size and trends, habitat use, ecology, threats and conservation actions for each species. A digital map of the geographic range of each species was also developed in a Geographic Information System. Supporting information for most African species was reviewed during the Old World Small Carnivore Red List Assessment workshop in Cuc Phuong National Park, Viet Nam, from 3 to 7 July 2006, and a preliminary assessment of the *IUCN Red List* status of these species was made using the *IUCN Red List Categories and Criteria version 3.1*. The remaining species were assessed and reviewed through email correspondence with experts. Finally, the Red List Authority Coordinators of the IUCN Species Survival Commission (SCC) Small Carnivore Specialist Group (SCSG) and the IUCN SCC Otter Specialist Group (OSG) reviewed the assessments. The former covers weasels and allies except otters (Mustelidae except Lutrinae), African Palm Civet (Nandiniidae), civets and allies (Viverridae) and mongooses (Herpestidae); the latter treats otters (Mustelidae: Lutrinae).

We defined small carnivores as species within the remits of the SCSG and OSG, and took the Suez Canal as the eastern boundary of Africa. We therefore do not consider Marbled Polecat *Vormela peregusna*, a Eurasian species recently discovered to inhabit the Sinai Peninsula of Egypt (Saleh & Basuony 1998), part of the African fauna. Madagascar was similarly excluded; no species, or even family, of carnivores is native to both Africa and Madagascar (Goodman 2012). Analysis and discussion treats only species native to Africa, including (pending further clarification) two species, both confined in mainland Africa to the north, for which origin in Africa is not clear. Contemporary research points to an anthropogenic introduction for Least Weasel *Mustela nivalis* (Dobson 1998, Lebarbenchon *et al.* 2010), but animals taxonomically close to Western Polecat *M. putorius* are speculated to be native (Gippoliti 2011, Ahmim 2013). Several mainland species occur on African islands, either naturally or through human transport (Appendix 2). Several non-African species have also been introduced to various African islands. These species are not included in analyses and discussion. As examples, Small Indian Civet *Viverricula indica* is found on Unguja, Pemba and Mafia Islands (Pakenham 1984, Kock & Stanley 2009) and Small Asian Mongoose *Herpestes javanicus* on Mafia Island (Kock & Stanley 2009). There seem to be no non-native small carnivores established in mainland Africa. Analyses of distributional and species-richness patterns cover only the countries of mainland Africa. Thus, the Macaronesian islands (various countries) and the island nation of Sao Tome and Principe were excluded. None of these archipelagos is believed to support native small carnivores (Appendix 2). These country-based analyses also ignore the two European exclaves in mainland Africa, Ceuta and Melilla (Spain; total 30.8 km^2); we traced no information on which small carnivore species these support.

The classification for African small carnivores on the *IUCN Red List* (see Appendix 1) currently largely follows Wozencraft (2005), although Sokoke Dog Mongoose *Bdeogale omnivora* and Congo Clawless Otter *Aonyx congicus* were considered conspecific with Bushy-tailed Mongoose *B. crassicauda* and African Clawless Otter *Aonyx capensis*, respectively, by Wozencraft (2005). The many points of taxonomic uncertainty with African small carnivores mean that the species count presented in this paper (n = 55) is sure to change, perhaps substantially, with further research involving both molecular techniques and morphological analyses. For example, South African Small-spotted Genet *Genetta felina* (Fig. 2) is now widely recognised as distinct (e.g. Gaubert *et al.* 2004, 2005, Jennings & Veron 2009) although not universally so (e.g. Delibes & Gaubert 2013, IUCN 2013) and, following the latter, is here considered conspecific with Common Genet *G. genetta*. *IUCN Red List* status and population trend information for each species refers to its global status, not to its status specific to Africa (some species also occur outside Africa; Appendix 1). Some data used in this paper are freely available online (IUCN 2013).

Fig. 2. South African Small-spotted Genet *Genetta (genetta) felina* (here one radio-collared individual from Great Fish River Reserve, South Africa) is now often treated as a species (Photo: E. Do Linh San).

In this study, species richness was defined as 1) the number of small carnivore species here assessed as occurring naturally in each of the 48 mainland African countries, and 2) species density, the number of species per 100,000 km² of country (see Appendix ES1). Species lists for each country were compiled from several sources (Appendix 1), including extensions of known range described in this special issue of *Small Carnivore Conservation*. Sudan and South Sudan are treated as a single unit, because most references did not differentiate between the former Southern Sudan autonomous region (which became a country in 2011) and the residual Sudan in terms of species presence or absence. We used Generalized Linear Models (GzLMs) to test whether species threat level is associated with the extent of species distribution, expressed as the number of countries in which each species is indicated to occur by these sources, or its range area as in the *IUCN Red List*. For this purpose, *IUCN Red List* categories were converted to an ordinal scale according to an increasing threat level (Least Concern = 1, Near Threatened = 2, Vulnerable = 3). The five Data Deficient species and the three species with only a small proportion of their world range in Africa (see Appendix 1) were excluded from analyses. A multinomial distribution and a cumulative logit function were used to generate GzLMs, and the finite sample corrected Aikaike's Information Criterion (AICc) was used to compare the models (Norušis 2008). Potential significant differences between threat level categories were further tested with Mann-Whitney *U* tests. Similarly, we tested whether species richness is affected by four possible predictors (or covariates) reflecting country size, human density and societal development: country area (km²), number of inhabitants/km², gross national product (GNP) per inhabitant (US$) and gross domestic product (GDP) per inhabitant (US$) (raw data in Appendix ES1). Negative binomial distributions and log link functions were used for the count variable (absolute species number), whereas gamma distributions and power functions were used to model the continuous variable (average number of species per 100,000 km² of country). For the negative binomial distributions, the dispersion parameter k was set at 0.1. The ratio of the deviance to its degree of freedom was close to 1 for the response variable in all the models, indicating that the variability in observed data was similar to that predicted by the underlying distributions used for the models (Norušis 2008). Before conducting GzLMs, we assessed multicollinearity of predictor variables using Spearman rank correlation; variables considered highly correlated ($r_S > 0.3$, $P < 0.05$) were not included in the same models. As suggested by Norušis (2008), in all GzLMs the scale parameter was estimated by dividing the deviance by its degrees of freedom. The possible effects of independent variables were evaluated with a Type III test, which does not depend on the entry order of variables (Norušis 2008). The significance level for all analyses was set at $\alpha < 0.05$.

Results

Under the *IUCN Red List*'s taxonomy, four families of small carnivores occur partly or entirely (Nandiniidae; monospecific) in Africa, encompassing 23 genera and 55 species. The most speciose family in Africa is Herpestidae (26 species, 47% of African small carnivore species), followed by Viverridae (17 species, 31%) and Mustelidae (11 species, 20%). On average, mainland African countries contain 15 (SD = 5.5) small carnivore species (Table 1). Countries of greatest species richness occur in equatorial Africa (countries roughly within 15° of the Equator) although most sub-Saharan countries hold more than 15 species (Fig. 3; Appendix ES1). Lowest per-country species richness is in North Africa. The pattern is somewhat different when using each country's species density as an index. On average, each country contains 13.5 (SD = 24) species per 100,000 km² of its area (Table 1). Figure 3 (right map) shows that several small African countries (The Gambia, Guinea Bissau, Sierra Leone, Liberia, Togo, Benin, Equatorial Guinea, Eritrea, Djibouti, Rwanda, Burundi, Malawi, Swaziland, Lesotho) host more species per unit area of country than do larger, neighbouring countries. This is because the calculated country-specific species density is affected by both true species richness per 100,000 km² (i.e. the number of species per 100,000 km² block, irrespective of country boundaries) and by country size (i.e. the size of the block used to derive the country-specific species density). However, species density is again lower in North Africa. Most countries fall on or very close to the indicated power regression curve (Fig. 4), suggesting that most of the variation in this character stems from a basic relationship of species richness increasing with country area, but not in linear proportion. However, two countries (Western Sahara and Tunisia) lie noticeably below the curve, indicating that these countries (both dominated by poorly-vegetated arid habitats) support anomalously few species for their area. Perhaps surprisingly, no country supports an unexpectedly large number

Table 1. Small carnivore species richness and density in mainland African countries and size, demographic and socio-economic characteristics of those countries.

	n	Average	Standard deviation	Minimum	Maximum
Species per country[1]	48	14.92	5.61	3	26
Species density[2]	48	13.56	24.06	0.17	134.87
Country area (km²)	48	579,996	584,636	10,380	2,381,740
Number of inhabitants/km²	48	74.22	95.36	2.04	448.26
GNP[3]/inhabitant (US$)	47[3]	969	1,308	66	5,398
GDP[3]/inhabitant (US$)	47[3]	2,729	4,906	231	29,332

[1]The two countries Sudan and South Sudan are treated as one unit; countries with only island and/or exclave territory in Africa are omitted (see text).
[2]Number of species per 100,000 km² of a country.
[3]GNP = Gross National Product, GDP = Gross Domestic Product; no data were available for Western Sahara. Data country by country are provided in Appendix ES1.

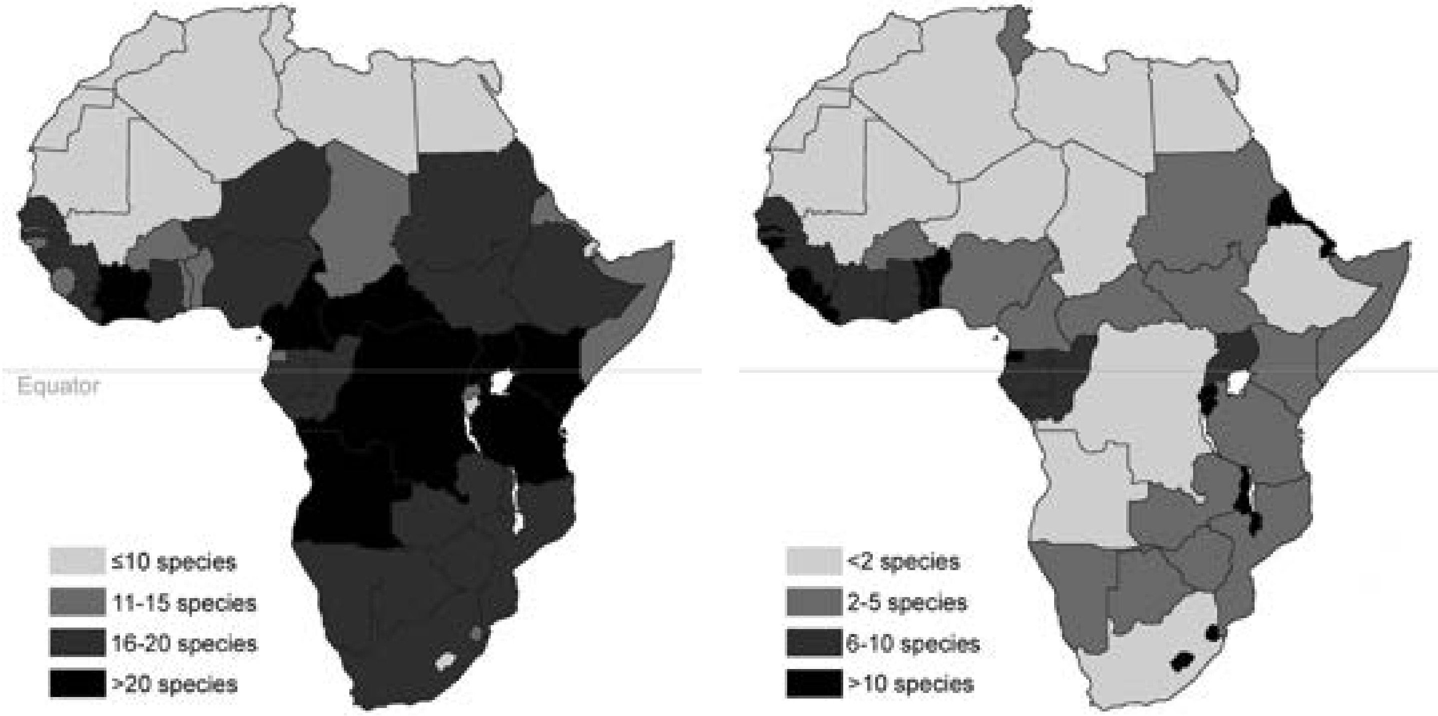

Fig. 3. Country-based species richness of small carnivores in continental Africa based on the *IUCN Red List* and overview and location of mainland African countries (countries with only island territory in Africa were not included in the comparison; and Sudan and South Sudan were treated as one unit). Left: species richness per country; right: species density, i.e. number of species per 100,000 km² of country.

of species for its area. The results of the GzLM procedure indicated that the intercept-only model had a greater explanatory power (Omnibus Test, $P > 0.13$) than the fitted models including different combinations of predictors; hence, none of the covariates ($P > 0.13$) affected country species richness. In contrast, several fitted models explained better the variation in country species density than did the intercept-only model (Omnibus Test, $P \leq 0.014$; Table 2). Univariate models showed that 'Country area' ($B = -2.071 \times 10^{-7}$, Wald $\chi^2 = 141.578$, $df = 1$, $P < 0.001$) and 'GNP/inhabitant' ($B = -0.003$, Wald $\chi^2 = 23.048$, $df = 1$, $P < 0.001$) were negatively, and the 'Number of inhabitants/km^2, positively ($B = 5.025$, Wald $\chi^2 = 6.112$, $df = 1$, $P = 0.013$), associated with country species richness. However, the best model incorporated 'Country area' ($B = -4.339 \times 10^{-7}$, Wald $\chi^2 = 128.434$, $df = 1$, $P < 0.001$) and 'GNP/inhabitant' ($B = -5.956 \times 10^{-5}$, Wald $\chi^2 = 5.114$, $df = 1$, $P = 0.024$) (Table 2).

Of the 55 small carnivore species native to Africa, 51 (93%) are predominantly African and 48 (87%) are endemic (Appendix 1). Ratel *Mellivora capensis* is the only species with large proportions of its range both in and outside Africa. In terms of conservation status, the *IUCN Red List* indicates that 43 species (78%) are Least Concern (LC), three (6%) are Near Threatened (NT), four (7%) are Vulnerable (VU) and five (9%) are Data Deficient (DD). No African small carnivore species are listed as Endangered (EN), Critically Endangered (CR), Extinct in the Wild (EW) or Extinct (EX).

All four species considered globally threatened (all VU; Sokoke Dog Mongoose, Liberian Mongoose *Liberiictis kuhni*, Crested Genet *Genetta cristata* and Johnston's Genet *G. johnstoni*) were listed under the A Criterion (population decline) (Appendix 1). None was listed using the B Criterion (geographic range size), C Criterion (population size and decline), D Criterion (very small or restricted population) or E Criterion (quantitative analysis). Similarly, the three NT species (Jackson's Mongoose *Bdeogale jacksoni*, Bourlon's Genet *G. bourloni* and Eurasian Otter *Lutra lutra*) were listed using the A Criterion (Appendix 1). All threatened and two of the three NT small carnivore species are endemic to Africa, while Eurasian Otter is widespread across Eurasia (Appendix 1). While for

Table 2. Results of the GzLM procedures (Omnibus tests) testing the potential effects of country size (km²) and demographic and socio-economic characteristics on country-specific small carnivore species density, i.e. species richness per 100,000 km² of a country's area.

Variables in the alternative GzLMs	Power	Scale	LR χ^2	*df*	*P*	AICc
Country area, GNP/inhabitant	0.20	0.988	55.356	2	<0.001	292.714
Country area, GDP/inhabitant	0.14	1.000	54.178	2	<0.001	293.235
Country area	0.10	0.975	57.937	1	<0.001	294.046
Number of inhabitants/km²	2.20	1.549	19.426	1	<0.001	320.440
GNP/inhabitant	1.00	1.922	6.074	1	0.014	333.455
GDP/inhabitant	0.20	2.176	0.131	1	0.717	344.845

GzLM = Generalized Linear Model, LR = Likelihood Ratio, AICc = finite sample corrected Akaike's Information Criterion, GNP = Gross National Product (US$), GDP = Gross Domestic Product (US$).
Only models incorporating uncorrelated predictors were considered.

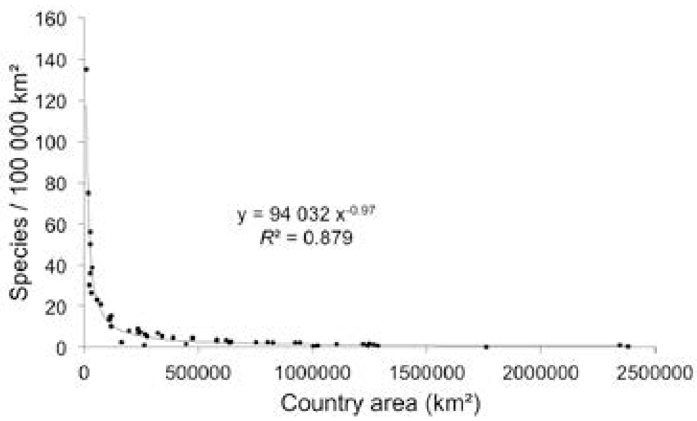

Fig. 4. The relation of country-based species density of small carnivores in continental Africa with country area. Line represents a fitted power function regression curve.

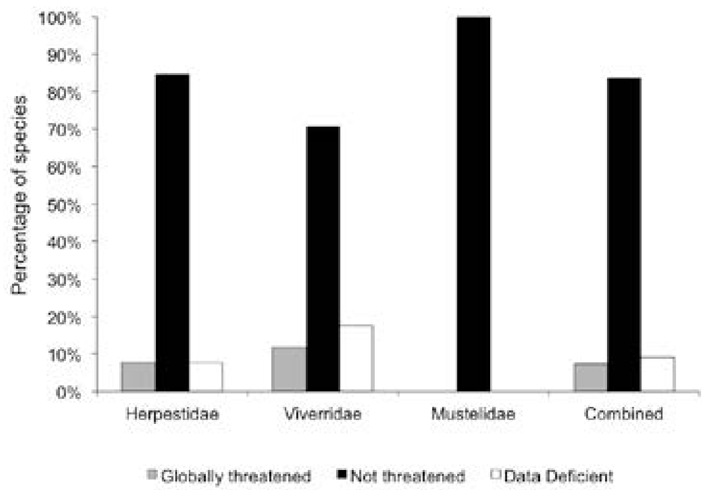

Fig. 5. Threat levels of small carnivore species by family in Africa based on the *IUCN Red List*. The family Nandiniidae, monospecific (LC), is not displayed but has been taken into account in the overall evaluation (category 'Combined'). Note that Near Threatened is a category of 'not threatened', not of 'globally threatened'.

data-sufficient small carnivore species, 8% were considered threatened (Fig. 5), the exact threat level is between 7% (if no DD species is threatened) and 16% (if all are).

As could be expected, the range area and the number of countries in which each African small carnivore species occur are highly positively correlated (Spearman rank correlation, $r_S = 0.915$, $P < 0.001$). The GzLM procedure indicated that 'Range area' is negatively associated with an increase in small carnivore threat level ($B = -9.36 \times 10^{-6}$, Wald $\chi^2 = 17.727$, $df = 1$, $P < 0.001$, AICc = 26.708). A model integrating 'Number of countries' even had a slightly better explanatory power, with an increase in the number of countries being linked to a decrease in species threat level ($B = -0.383$, Wald $\chi^2 = 17.258$, $df = 1$, $P < 0.001$, AICc = 23.721). Vulnerable and Near Threatened small carnivores have typically more restricted ranges than Least Concern species (Table 3). Overall, Least Concern species occur in more countries (Mann-Whitney *U* test, $n_1 = 43$, $n_2 = 7$, $U = 59$, $P = 0.009$) and have larger geographic ranges ($n_1 = 41$, $n_2 = 6$, $U = 7$, $P < 0.001$) than do Vulnerable and Near Threatened species combined. Data Deficient species possess even more restricted distribution ranges than do threatened species (Table 3).

The percentage of species considered globally threatened varies across families, from 0% (Mustelidae and Nandiniidae) to about 8% in Herpestidae and 12% in Viverridae (Fig. 5). There are no DD species in the family Mustelidae, in contrast to about 8% of species of Herpestidae and 18% of Viverridae being so classified (Fig. 5). The geographic distribution of DD species includes equatorial African countries (Côte d'Ivoire, Liberia, Ghana, Equatorial Guinea, Republic of Congo, Central African Republic, Uganda and Democratic Republic of Congo), as well as Angola and Sudan. Treating only data-sufficient species, the percentage of threatened species increases slightly to 14% for Viverridae, while remaining 8% for Herpestidae.

Overall, population trends for 46% ($n = 25$) of small carnivore species in Africa are assessed as unknown globally, including 27% of species of Mustelidae, 35% of Herpestidae and 71% of Viverridae (Fig. 6). Of the 30 species with assessed population trends, 50% (27% of species overall) are believed to be stable and 50% (27%) to be decreasing; none is thought to be increasing.

Discussion

Small carnivores in Africa represent 34% of the extant small carnivores worldwide ($n = 163$ species; Schipper *et al.* 2008a). Familial richness is intermediate, with four of the world's nine families represented (Ailuridae, Eupleridae, Mephitidae, Procyonidae and Prionodontidae are all extralimital). Country species richness was not affected by country size, human population density or by coarse-scale socio-economic indices. At first glance, greatest species richness of small carnivores

Table 3. Distribution of small carnivores in Africa, compared based on their *IUCN Red List* category.

***Red List* category**	**Number of species[1] in Africa**	**Number of mainland countries per species**			
		Mean	**Standard deviation**	**Minimum**	**Maximum**
LC	43	15.72	14.40	1	44
NT	3	3.33	0.58	3	4
VU	4	3.75	1.71	2	6
DD	5	2.80	1.64	1	5
Total	**55**	**13.02**	**13.76**	**1**	**44**
***Red List* category**	**Number of species[2] in Africa**	**Geographic range area per species (km²)**			
		Mean	**Standard deviation**	**Minimum**	**Maximum**
LC	41	5,785,851	6,614,627	43,777	28,885,834
NT	2	105,408	58,626	63,953	146,863
VU	4	129,949	121,033	34,426	306,732
DD	5	298,473	236,848	49,336	602,126
Total	**52**	**4,604,671**	**6,294,881**	**34,426**	**28,885,834**

LC = Least Concern, NT = Near Threatened, VU = Vulnerable, DD = Data Deficient.
[1]Comparison considers all species of small carnivores occurring in Africa.
[2]Comparison omits the three species in Africa (*Mustela nivalis*, '*M. putorius*' and *Lutra lutra*) with ranges predominantly in other continents.

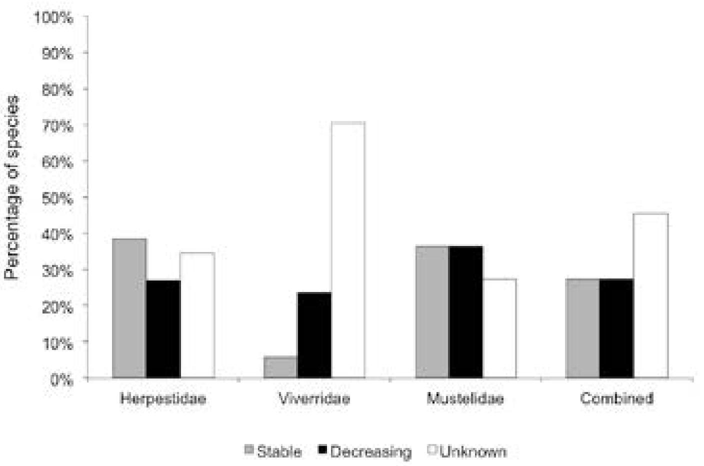

Fig. 6. Global population trends of small carnivore species by family in Africa based on the *IUCN Red List*. The family Nandiniidae, monospecific (unknown population trend), is not displayed but has been taken into account in the overall evaluation (category 'Combined').

in Africa seems to follow the general pattern of overall land mammal species richness (Schipper *et al.* 2008b) and of small carnivore species richness in the Americas (Belant *et al.* 2009), peaking in the tropics and therefore in areas of high ecological and possibly topographic complexity. Small carnivore species richness generally declines with increasing latitude (Belant *et al.* 2009). In Africa, small carnivore richness is indeed lower in the north, but not in the south, suggesting that the low productivity of the vast and arid Sahara might explain the observed difference. That country species density was markedly greater in smaller countries throughout Africa indicates that as country size increases, the number of 'new' habitats favourable to host additional, possibly more 'specialised' small carnivore species does not increase in proportion. These results support the notions that although some habitat size threshold might be essential to ensure population viability (e.g. Crawley & Haral 2001, Brito & Grelle 2006) and that the larger an area the more species generally it will hold (Ruggiero *et al.* 1994), area *per se* is not the only variable for explaining local patterns of mammalian species richness. For conservation purposes, other factors such as habitat diversity and species interactions should be taken into account when assessing species richness and diversity at the landscape scale (Fox & Fox 2000). Human population density was positively associated with country species richness. This could suggest that an increase in potential human population pressure might not necessarily be detrimental to small carnivores, at least for generalist species that are probably less sensitive to habitat change. However, it could as well indicate that areas productive for people, and thus supporting higher human population densities, are also inherently rich in small carnivore species. If indeed so, this might mean that species-rich small carnivore communities are more likely to be threatened by, or in conflict with, humans. This situation would add to conservation challenges. Precise data on small carnivore species compositions and densities in human-populated areas would be needed for firm conclusions.

Based on extinction risk as measured by the *IUCN Red List*, small carnivore species in Africa appear more secure than small carnivores or mammals globally. However, this comparison requires a caveat. Assessments of species status always contain some degree of uncertainty and the particularly low levels of knowledge for many African species mean that they are at elevated risk of incorrect assessment. That said, 'only' 8% of data-sufficient African small carnivores were assessed as globally threatened, compared with 20% in the Americas (Belant *et al.* 2009) and 22% worldwide (Schipper *et al.* 2008a). Overall, 25% of all mammals worldwide are considered globally threatened (Schipper *et al.* 2008b). In Africa, the four globally threatened (in this case Vulnerable) and two of the Near Threatened species were listed as such by the *IUCN Red List* based on an estimated population decline. Most African small carnivores have distribution ranges that well exceed the thresholds for listing under the B criterion. However, an increase in threat levels is associated with a decrease in range areas (see above). All five DD species have extremely small ranges and considering the likely threats to such species (see below), the comparatively low threat levels to African small carnivores provided above should be interpreted with caution. In addition, even some LC species would benefit from clarification of conservation status.

Threats to the globally threatened African small carnivores vary between species. Sokoke Dog Mongoose, restricted to coastal forests of Kenya and Tanzania, is believed to have declined substantially through impacts of extensive, ongoing habitat loss related to illegal logging (Taylor 2013). In the Shimba Hills National Reserve (Kenya), the resident population was, and might still be, under potential threat from afforestation with non-native pines *Pinus* together with regular burning of the undergrowth to favour Sable Antelope *Hippotragus niger grazing* (Engel & Van Rompaey 1995). In West Africa, both Liberian Mongoose and Johnston's Genet lose habitat to agriculture, logging and mining within their Upper Guinea forests ranges, and are hunted (mostly for meat and skin) with dogs, shotguns and snares (Dunham & Gaubert 2013, IUCN 2013). The lack of den sites in secondary forests might restrict Liberian Mongoose distribution, while in forest plantations this species might also suffer from pesticide use, because the worms it forages on accumulate toxins to levels threatening to mammalian predators (Taylor & Dunham 2013). For Crested Genet, endemic to Nigeria and Cameroon, and perhaps the Republic of Congo and Gabon (Hunter & Barrett 2011), habitat loss is probably also a major threat (Gaubert *et al.* 2006), because the non-protected Cross River State forests (Nigeria) are gradually being converted into farms or wastelands and the Niger Delta is exploited as an oil-production area (Angelici & Luiselli 2005). It probably also suffers from high hunting pressure (Van Rompaey & Colyn 2013a).

Among the Near Threatened species, little is known about threats to Eurasian Otter in its limited African range (Algeria, Morocco and Tunisia). These populations have shown little sign of recovery, unlike those in parts of Europe. In Morocco, pollution has increased dramatically in the major rivers, especially in the north, where otters have apparently disappeared from rivers in the lowland plains, and dam building has also reduced habitat and fragmented populations (Delibes *et al*. 2012, Kruuk 2013). Jackson's Mongoose is thought to have declined by 20–25% over the 15 years preceding the *IUCN Red List* assessment (IUCN 2013). Its probable dependence on forest means its main threat is likely to be ongoing clearance at the restricted number of sites in Uganda, Kenya and Tanzania it occupies (Van Rompaey & Kingdon 2013). Protection of such forests is crucial, and other East African groundwater-dependent forests should be surveyed for Jackson's Mongoose (De Luca & Rovero 2006). Bourlon's Genet is essentially restricted to the Upper Guinean rainforests (see countries in Appendix ES1) and is believed to have declined by more than 20% over the 20 years prior to 2008 based on estimates of ongoing forest loss (although not as severe in Liberia, the core of the species's range, as elsewhere in Upper Guinea; Papeş & Gaubert 2007), coupled with the likely impacts of hunting (IUCN 2013). All Vulnerable and Near Threatened small carnivore species are in need of further survey work to clarify their conservation status (distribution and population density/trends) in the wild, and also, when relevant, to determine sustainable levels of offtake from the wild and general management and conservation measures.

The percentage of small carnivores in Africa with inadequate data to assess conservation status (i.e. Data Deficient; 9%) is similar to that of small carnivores in the Americas (11%; Belant *et al.* 2009) and worldwide (9%; Schipper *et al.* 2008a), and slightly lower than the percentage of such land mammals overall (15%; Schipper *et al.* 2008b). Categorising a species as Data Deficient means that insufficient information is available to evaluate ongoing threats and/or there is serious doubt that species rank is taxonomically appropriate. Taxonomic uncertainty does not drive the DD listing for any of the five African small carnivores so categorised. Pousargues's Mongoose *Dologale dybowskii* is perhaps the least known African small carnivore: known from only 31 specimens, it has not been conclusively recorded in several decades (Stuart & Stuart 2013; but see Aebischer *et al*. 2013). Aquatic Genet *Genetta piscivora* from Democratic Republic of Congo is also poorly known, rarely observed, and taken as bushmeat (Van Rompaey & Colyn 2013b); it may possibly warrant listing under criteria A or C. The taxonomically recently resurrected King Genet *G. poensis* has a disjunct distribution in forest from Liberia to Republic of Congo and although not reliably recorded for over 50 years, this likely reflects confusion with other genets, so it may well be more common than it seems (Gaubert 2003, 2013). West African Oyan *Poiana leightoni* has a very narrow distribution in the upper Guinean forests (Van Rompaey & Colyn 2013c), and may have a status akin to that of other co-occurring species with similar narrow ranges, such as Johnston's Genet (VU) and Liberian Mongoose (VU). Finally, Ansorge's Cusimanse *Crossarchus ansorgei* from Central Africa is poorly known (Van Rompaey & Colyn 2013e), but likely to be listed as Least Concern with further information (IUCN 2013). Only further research and survey work can clarify the population status, trends and threats of these species. These Data Deficient species occur primarily in equatorial Africa, making this one region where investigation and research efforts should be concentrated.

Finally, populations of mainland species on islands might be worth investigating in further detail, especially endemic subspecies perhaps under threat. In Zanzibar, Goldman & Winther-Hansen (2003) mentioned three such endemic subspecies: Servaline Genet *Genetta servalina archeri*, Common Slender Mongoose *Herpestes sanguineus rufescens* and Bushy-tailed Mongoose *Bdeogale crassicauda tenuis*.

The overall assessed conservation status of African small carnivores is relatively favourable compared with mammals worldwide. However, the four Vulnerable and three Near Threatened species warrant specific interventions to ensure their persistence, yet for none does there seem to be a conservation programme in place to remove and/or mitigate the factors threatening it. Effective action for these species is the short-term priority for small carnivore conservation in Africa. In future the threat levels of African small carnivores are likely to worsen. At least a quarter are assessed by IUCN (2013) as already in decline. All major threats originate from people, and with Africa having the highest human population growth rate of any continent (UN 2011), existing threats will surely intensify and probably diversify. The high demand for wildlife meat and other products in East Asia is not abating and already animals much declined in Asia are sourced from Africa to meet this demand (Bennett 2011). Small carnivores are a large part of Asian wildlife trade (e.g. Bell *et al*. 2004) and, as their South-east Asian populations decline they are likely to join the trade from Africa to East Asia. Simultaneously, continued high levels of evergreen forest conversion and fragmentation are reducing habitat block size (Newmark 1998), meaning that the species of those habitats will become increasingly susceptible to hunting even if levels remain constant. Altogether, this suggests that additional African small carnivore species will meet globally threatened criteria if no effective conservation strategies are implemented, in particular to combat wildlife meat trade and illegal logging. Considering the paucity of information available on this fascinating group of species and the high level of endemism of small carnivores in Africa, both research and conservation will be of prime importance in the future.

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Additional material related to this paper* can be found as a PDF file (SCC48_Appendix-ES1.pdf) on the SCC website in the following link: http://www.smallcarnivoreconservation.org/home/journal/SCC48_Appendix-ES1.

***Appendix ES1.** Raw data for each African country used in analyses including individual lists of species reported in each country.

Appendix 1. Taxonomic affiliation, conservation status, population trends and distribution of small carnivores in Africa.

Taxon[1]	English name	*IUCN Red List* categorisation[2]	Population trend	Number of countries[3]	Distribution
Family Mustelidae					
Mustela nivalis[4]	Least (Common) Weasel	LC	Stable	2	Eurasia, North America, North Africa
Mustela subpalmata (*M. nivalis subpalmata*)	Egyptian Weasel	LC	Stable	1	Africa
Mustela putorius[4]	Western (European) Polecat (Ferret?)	LC	Decreasing	2	Europe, North Africa
Ictonyx libycus[5] (*Poecilictis libyca*)	Libyan (Libyan Striped, Saharan Striped, North African Striped) Weasel (Saharan Striped Polecat)	LC	Unknown	15	Africa
Ictonyx striatus	Zorilla (Striped Polecat, African Polecat)	LC	Stable	39	Africa
Poecilogale albinucha	African Striped (Striped, African, White-naped, Snake) Weasel	LC	Unknown	17	Africa
Aonyx capensis	African (Cape) Clawless Otter	LC	Stable	36	Africa
Aonyx congicus (*A. capensis congicus*)	Congo (Cameroon, Small-toothed) Clawless (Swamp) Otter	LC	Unknown	9	Africa
Lutra lutra	Eurasian (Common) Otter	NT (A2cd)	Decreasing	3	Eurasia, North Africa
Lutra maculicollis (*Hydrictis maculicollis)*	Spotted-necked (Spot-necked, Speckle-throated) Otter	LC	Decreasing	34	Africa
Mellivora capensis	Honey Badger (Ratel)	LC	Decreasing	44	Africa, Arabia, South Asia

Taxon[1]	English name	*IUCN Red List* categorisation[2]	Population trend	Number of countries[3]	Distribution
Family Nandiniidae					
Nandinia binotata	African (Two-spotted) Palm (Tree) Civet	LC	Unknown	28	Africa
Family Viverridae					
Genetta abyssinica	Abyssinian (Ethiopian) Genet	LC	Unknown	5	Africa
Genetta angolensis	Angolan (Miombo) Genet	LC	Unknown	6	Africa
Genetta bourloni	Bourlon's Genet	NT (A2cd)	Decreasing	4	Africa
Genetta cristata	Crested (Crested Servaline) Genet	VU (A2cd)	Decreasing	4	Africa
Genetta genetta[6]	Common (Small-spotted) Genet	LC	Stable	37	Africa, South-west Europe, Arabia
Genetta johnstoni	Johnston's Genet	VU (A2cd)	Decreasing	6	Africa
Genetta maculata	Rusty-spotted (Blotched, Central African Large-spotted, Large-spotted) Genet	LC	Unknown	31	Africa
Genetta pardina	Pardine (West African Large-spotted) Genet	LC	Unknown	11	Africa
Genetta piscivora	Aquatic Genet	DD	Unknown	1	Africa
Genetta poensis	King Genet	DD	Unknown	5	Africa
Genetta servalina	Servaline Genet	LC	Unknown	11	Africa
Genetta thierryi	Hausa (Haussa) Genet	LC	Unknown	13	Africa
Genetta tigrina	Cape (South African Large-spotted) Genet	LC	Unknown	2	Africa
Genetta victoriae	Giant (Giant Forest) Genet	LC	Unknown	3	Africa
Poiana leightoni	Leighton's (West African) Oyan (Leighton's Linsang, West African Linsang)	DD	Decreasing	2	Africa
Poiana richardsonii	Central African Oyan (African, Central African Linsang)	LC	Unknown	6	Africa
Civettictis civetta	African Civet	LC	Unknown	37	Africa
Family Herpestidae					
Atilax paludinosus	Marsh (Water) Mongoose	LC	Decreasing	37	Africa
Herpestes naso (*Xenogale naso*)	Long-nosed (Long-snouted) Mongoose	LC	Decreasing	10	Africa
Herpestes flavescens (*Galerella flavescens*)	Kaokoveld Slender (Angolan Slender, Black, Larger Red) Mongoose	LC	Stable	2	Africa
Herpestes ichneumon	Egyptian (Large Grey) Mongoose (Ichneumon)	LC	Stable	44	Africa, South-west Europe, Middle East
Herpestes ochraceus (*Galerella ochracea*)	Somali (Somalian) Slender Mongoose	LC	Unknown	3	Africa
Herpestes pulverulentus (*Galerella pulverulenta*)	Cape (Small) Grey Mongoose	LC	Stable	3	Africa
Herpestes sanguineus (*Galerella sanguinea*)	Common Slender (Slender) Mongoose	LC	Stable	39	Africa
Bdeogale crassicauda	Bushy-tailed Mongoose	LC	Unknown	7	Africa
Bdeogale jacksoni	Jackson's Mongoose	NT (A2cd)	Decreasing	3	Africa
Bdeogale nigripes	Black-footed (Black-legged) Mon-goose	LC	Decreasing	6	Africa
Bdeogale omnivora (*B. crassicauda omnivora*)	Sokoke Dog (Sokoke Bushy-tailed) Mongoose	VU (A2c)	Decreasing	2	Africa
Rhynchogale melleri	Meller's Mongoose	LC	Unknown	8	Africa
Cynictis penicillata	Yellow Mongoose	LC	Stable	6	Africa
Paracynictis selousi	Selous's Mongoose	LC	Unknown	8	Africa
Ichneumia albicauda	White-tailed Mongoose	LC	Stable	33	Africa, Arabia

Taxon[1]	English name	*IUCN Red List* categorisation[2]	Population trend	Number of countries[3]	Distribution
Suricata suricatta	Meerkat (Suricate, Slender-tailed Meerkat, Grey Meerkat)	LC	Unknown	4	Africa
Mungos gambianus	Gambian Mongoose	LC	Stable	10	Africa
Mungos mungo	Banded Mongoose	LC	Stable	33	Africa
Liberiictis kuhni	Liberian Mongoose	VU (A2cd)	Decreasing	3	Africa
Dologale dybowskii	Pousargues's (Savannah) Mongoose	DD	Unknown	4	Africa
Helogale hirtula	Somali (Ethiopian, Desert) Dwarf Mongoose	LC	Stable	3	Africa
Helogale parvula	Common Dwarf (Dwarf) Mongoose	LC	Stable	15	Africa
Crossarchus alexandri	Alexander's Cusimanse	LC	Decreasing	4	Africa
Crossarchus ansorgei	Ansorge's (Angolan) Cusimanse (Angolan Mongoose)	DD	Unknown	2	Africa
Crossarchus obscurus	Common (Long-nosed) Cusimanse	LC	Unknown	5	Africa
Crossarchus platycephalus (*C. obscurus platycephalus*)	Cameroon (Flat-headed) Cusimanse	LC	Unknown	7	Africa

[1]Genus and species limits and spellings follow IUCN (2013), itself based on Wozencraft (2005), selected to be a readily available, widely used, source. Some of the more widely-used alternative taxonomic treatments and English names are given, but listings are far from comprehensive. Notably, genet taxonomy has been particularly unstable recently.
[2]DD = Data Deficient, LC = Least Concern, NT = Near Threatened, VU = Vulnerable; A2 = Population reduction observed, estimated, inferred, or suspected in the past where the causes of reduction may not have ceased or may not be understood or may not be reversible, c = assessment for category 'A2' based on a decline in area of occupancy, extent of occurrence and/or habitat quality, d = assessment for category 'A2' based on actual or potential levels of exploitation (IUCN 2012).
[3]Refers to the number of mainland African countries in which each species is here taken to occur, based on Bronner *et al.* (2003), Saleh & Basuony (2005), Wozencraft (2005), Dinets (2011), Ahmim (2013), N. Avenant (verbally 2013), Bahaa-el-din *et al.* (2013), IUCN (2013), Kingdon *et al*. (2013), A. Monadjem (verbally 2013) and Pacheco *et al.* (2013). To some extent these sources provide generalised distributions; they are not restricted to verifiable records. So the pattern analyses undertaken here are based upon the plausible inferred distribution of each species, rather than specific validated records of each species in each country.
[4]The origins of *Mustela nivalis* and animals identified as *M. putorius* in North Africa remain unresolved (see text).
[5]*Ictonyx* is a masculine genus so this species's name is thus correctly *I. libycus*, not *I. libyca*.
[6]South African Small-spotted Genet is sometimes given species rank (see text).

Appendix 2. Endemic African small carnivores present on African islands[1].

Island name	Country	Taxon[2]	English name[2]	Remark(s)	References
Bioko	Equatorial Guinea	*Lutra maculicollis*	Spotted-necked Otter	Former resident; now extirpated; controversial[3]	Harrington *et al.* (2002), D'Inzillo Carranza & Rowe-Rowe (2013)
		Nandinia binotata	African Palm Civet	Possibly present; historically rare	Harrington *et al.* (2002), Van Rompaey & Ray (2013)
		Genetta maculata	Rusty-spotted Genet	Possibly present	Harrington *et al.* (2002), Angelici & Gaubert (2013)
		Genetta poensis	King Genet	Possibly present	Harrington *et al.* (2002), Gaubert (2003, 2013)
		Poiana richardsonii	Central African Oyan	Present	Harrington *et al.* (2002), Van Rompaey & Colyn (2013d)
Sao Tome Island[4]	Sao Tome and Principe	*Civettictis civetta*	African Civet	Purportedly introduced	Dutton (1994)
Pemba	Tanzania	*Atilax paludinosus*	Marsh Mongoose	Absent from Unguja	Pakenham (1984)
Unguja (Zanzibar)	Tanzania	*Nandinia binotata*	African Palm Civet	Present	Perkin (2004, 2005)
		Genetta servalina archeri	Servaline Genet	Present	Van Rompaey & Colyn (1998), Goldman & Winther-Hansen (2003)
		Civettictis civetta	African Civet	Present	Pakenham (1984), Stuart & Stuart (1998)
		Herpestes sanguineus rufescens	Common Slender Mongoose	Present	Pakenham (1984), Stuart & Stuart (1998), Goldman & Winther-Hansen (2003)

Island name	Country	Taxon[2]	English name[2]	Remark(s)	References
		Bdeogale crassicauda tenuis	Bushy-tailed Mongoose	Present	Pakenham (1984), Stuart & Stuart (1998), Goldman & Winther-Hansen (2003)
		Mungos mungo	Banded Mongoose	Purportedly intro-duced; no recent records	Pakenham (1984), Stuart & Stuart (1998), Goldman & Winther-Hansen (2003)

[1]The Macaronesian islands (the Azores, Madeira, Savage, Canary and Cape Verde archipelagos) contain no native species of small carnivore nor any introduced African endemics, although Least Weasel *Mustela nivalis* and Western Polecat *M. putorius* and/or Domestic Ferret *M. furo* have been introduced; past reports of Common Slender Mongoose *Herpestes sanguineus* on the Cape Verde archipelago are in error (Masseti 2010, Hazevoet & Masseti 2011).
[2]Alternative taxonomic treatments and names are given in Appendix 1.
[3]Extensively treated in the past as a subspecies of *Aonyx congicus*, *A. c. poensis*; now considered synonymous with *Lutra maculicollis* (d'Inzillo Carranza & Rowe-Rowe 2013).
[4]Also supports *Mustela nivalis*, purportedly introduced (Dutton 1994, Sheffield & King 1994).

Notes on the distribution and status of small carnivores in Gabon

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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 km², 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 otter 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.

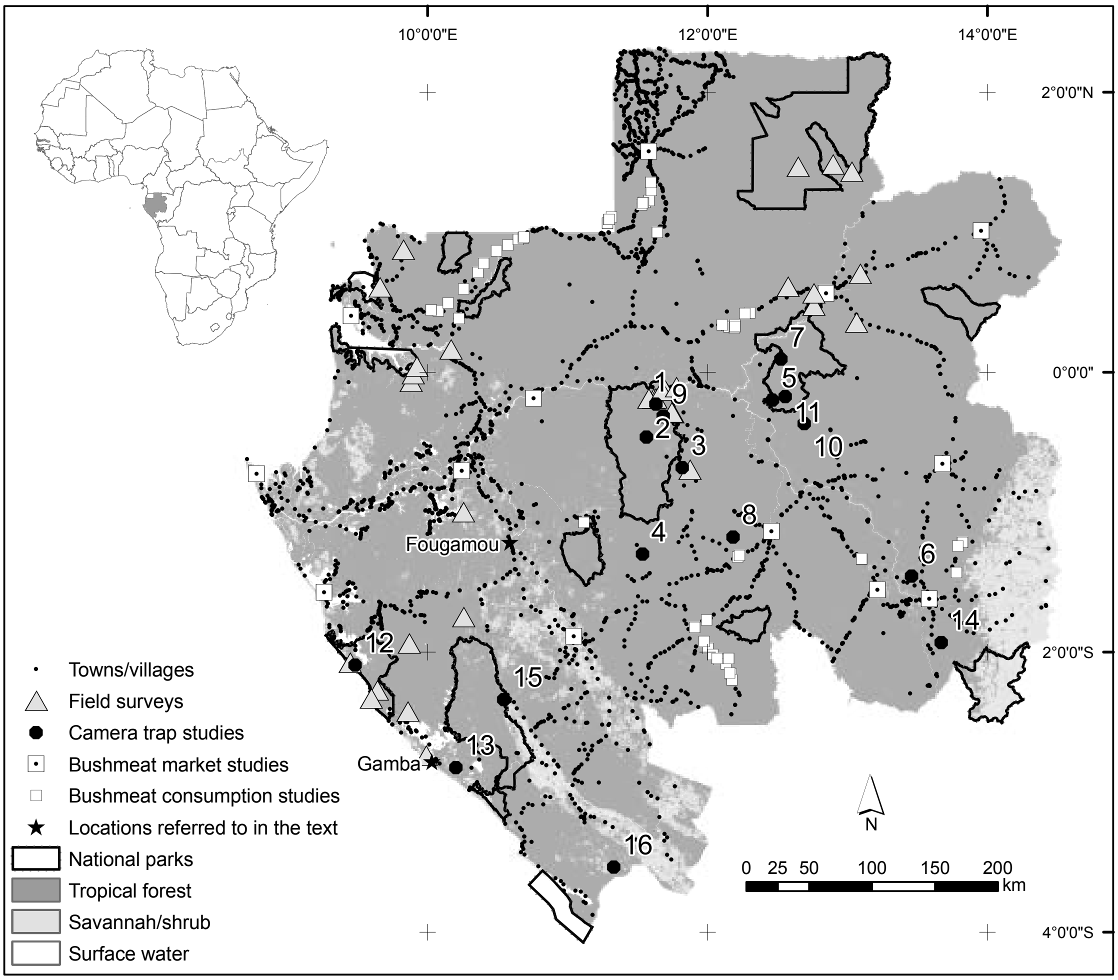

Fig. 1. Vegetation map of Gabon, showing population centres, protected areas and locations of the various surveys included in this study.

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

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

Sources: Hunter & Barrett (2011), IUCN (2012).
[1] See Fig. 3.
[2] 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[1]	Study species[2] 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 Marantacae 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 Marantacae 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

[1] Locations of camera-trap study sites are shown on Fig. 1. SEGC = Station d'Études des Gorilles et Chimpanzés.
[2] 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 uncover 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),

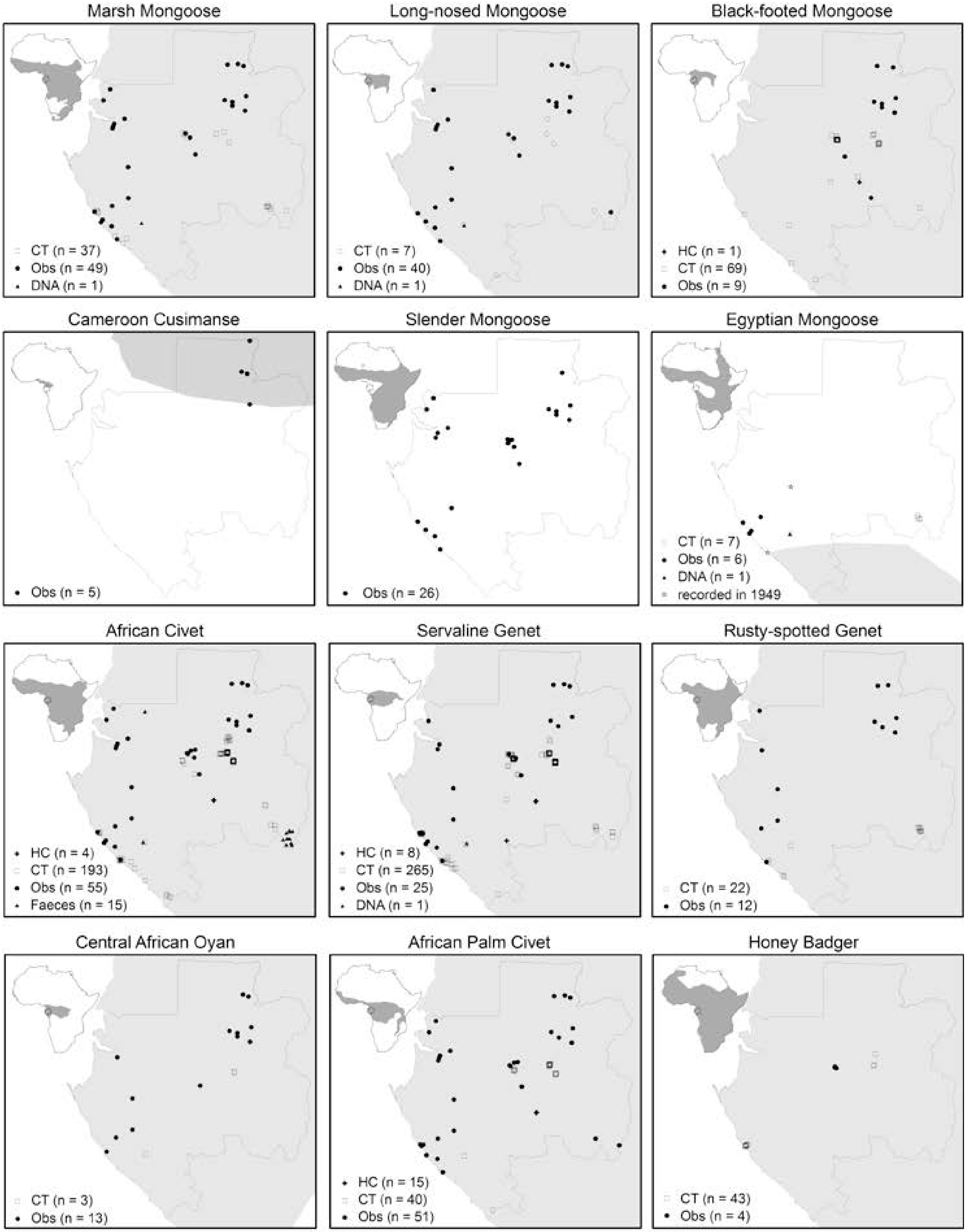

Fig. 3. Distribution maps for the small carnivores of Gabon, showing detection points. Grey shading represents generalised range according to *The IUCN Red List of Threatened Species*, both in the Gabon and the inset Africa maps (Data type: HC = hunter catch; CT = camera-trap record; Obs = direct observation;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

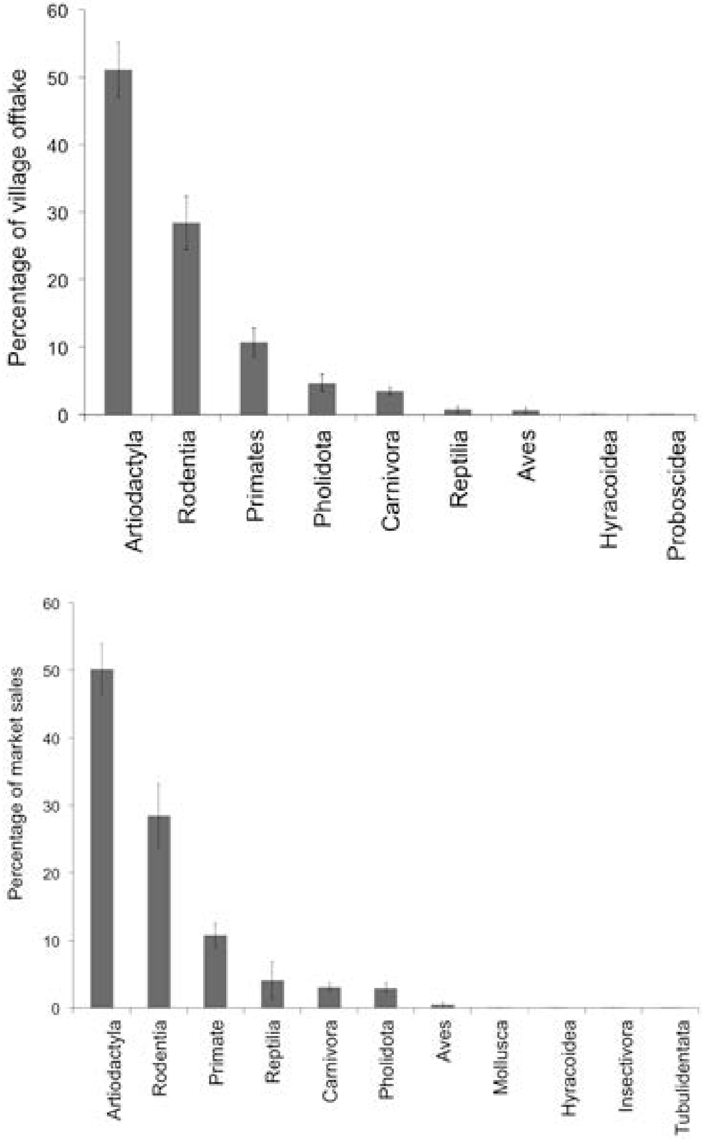

Fig. 4. Proportion of carnivores out of all animals (above) harvested in villages and (below) sampled at bushmeat markets during several surveys in Gabon (error bars represent the SE).

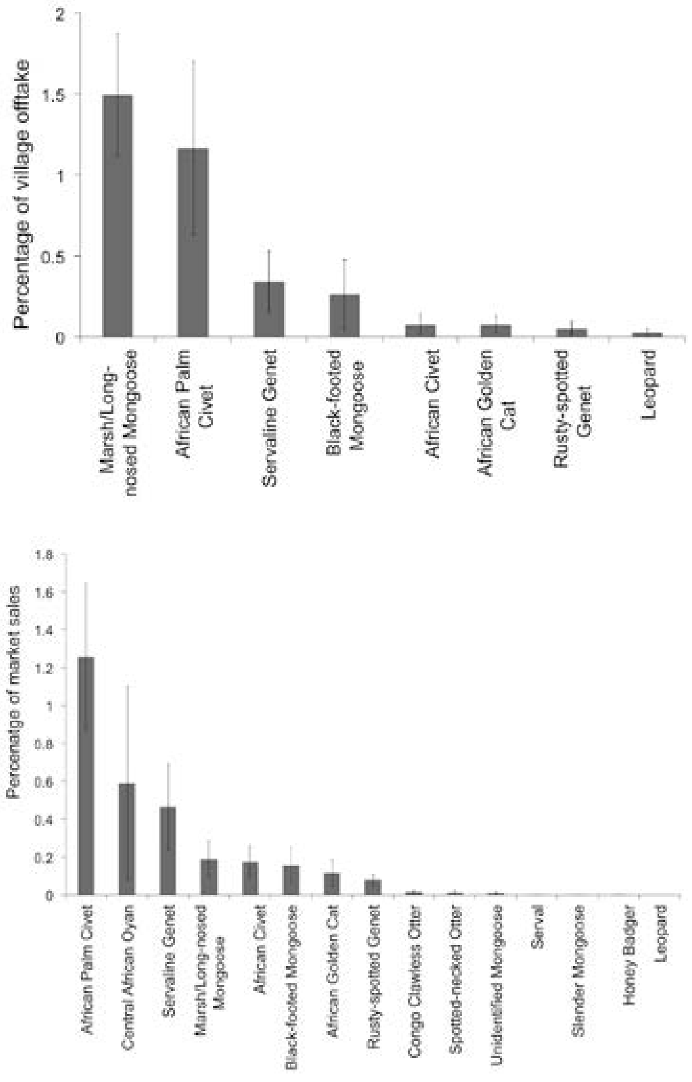

Fig. 5. Proportion of carnivores out of (above) total catch (number of animals) in villages and (below) total sample (number of animals) at bushmeat markets (error bars represent the SE). Scientific names are given in Table 1, save: African Golden Cat *Profelis aurata*; Leopard *Panthera pardus*; Congo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

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 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. Mazzocchetti 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 Egyptian Mongoose range and Rusty-spotted Genet habitat associations.

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).

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^2 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 (Mazzocchetti 2005). While traditional restrictions appear to be fading, the consumption of carnivores remains taboo for many ethnic groups, and in particular for women (Lahm 1993, Starkey 2004, Mazzocchetti 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 (Mazzocchetti 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.

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A survey of small carnivores in the Putu Mountains, southeast Liberia

Elizabeth J. GREENGRASS

Abstract

A recent survey of small carnivores in a commercial mining exploration concession at the Putu Mountains, southeast Liberia, involved a broad area reconnaissance and camera-trapping. Camera-trap images of the recently described Bourlon's Genet *Genetta bourloni* are the first published images of living individuals in the wild. This species is perhaps well distributed in the study area. Other small carnivore species found, including Honey Badger *Mellivora capensis*, are described. Liberian Mongoose *Liberiictis kuhni* was not detected, but local reports suggest that it was historically present and may persist at low density.

Keywords: *Genetta bourloni*, Liberian Mongoose, *Liberiictis kuhni*, mining, Ratel

Un inventaire des petits carnivores des montagnes de Putu, au sud-est du Libéria

Résumé

Un inventaire des petits carnivores conduit récemment dans une concession d'exploration minière commerciale dans les montagnes de Putu, au sud-est du Libéria, impliquait une reconnaissance générale de la région avec une étude basée sur le piégeage photographique. Des clichés de la Genette de Bourlon *Genetta bourloni*, décrite récemment, sont les premières images publiées d'individus vivants, en milieu sauvage. Cette espèce pourrait être bien distribuée dans la zone d'étude. D'autres espèces de petits carnivores qui ont été recensées, y compris le Ratel *Mellivora capensis*, sont décrites. La Mangouste du Libéria *Liberiictis kuhni* n'a pas été détectée, mais des mentions locales suggèrent qu'elle était présente par le passé et pourrait encore subsister à faible densité.

Mots clés: exploitation minière, *Genetta bourloni*, *Liberiictis kuhni*, Mangouste du Libéria, Ratel

Introduction

Globally, the species richness of small carnivores, as with mammals as a group, is greatest in tropical areas, with about one-third of all species occurring in the Afrotropical realm (Schipper *et al*. 2008). The ecological role of tropical small carnivores remains poorly studied (Mudappa *et al*. 2007) but it is thought that they are important as competitors, predators and prey. In addition, they may be important seed dispersers with a vital role in forest regeneration (e.g. Mathai *et al*. 2010). Their natural history is mostly poorly understood and the distribution ranges of many species remain speculative (e.g. Djagoun & Gaubert 2009).

Liberia is situated in the Upper Guinea forest region, a part of the Guinean Forest Biodiversity Hotspot, where "exceptional concentrations of endemic species are undergoing an exceptional degree of habitat loss" (Myers *et al*. 2000). The only country that lies entirely within this region, it accounts for almost half the estimated area of remaining Upper Guinea Forest. Sapo National Park (Sapo NP), Liberia's only national park, covering 180,363 hectares, is a significant portion of the remaining southeast lowland rainforest block in the country and is at the centre of a large forest mosaic that has potential to provide a secure habitat for many threatened species. It is the closest-to-intact forest ecosystem in Liberia and remains tenuously connected by forest corridors to several other forest blocks in the southeast, such as the Grebo National Forest and the Krahn–Bassa National Forest.

The Liberian forest block is recognised as a global centre for viverrid endemism (Hoppe-Dominik 1990) and the Upper Guinea forests are a global priority area for small carnivore conservation (Schreiber *et al*. 1989). Despite this, the status of small carnivores in these areas is poorly known. This region supports Liberian Mongoose *Liberiictis kuhni*, listed as Vulnerable on *The IUCN Red List of Threatened Species* (IUCN 2012). This global priority species for conservation (Schreiber *et al*. 1989) has a known distribution encompassing just a few forested locations in Liberia, including Sapo NP (Vogt *et al*. 2012), and Tai National Park in Côte d'Ivoire (Colyn *et al*. 1998). Discovered in 1958 (Schlitter 1974, Goldman & Taylor 1990) and considered a rainforest specialist, its range may already be shrinking with forest fragmentation and anthropogenic pressure (e.g. Taylor 1989), such as logging and the conversion of forest to farms. Liberia also contains the core habitat of the newly described Bourlon's Genet *Genetta bourloni* (Gaubert 2003) which is listed as Near Threatened on the *IUCN Red List* (IUCN 2012) and is restricted to the Upper Guinea forests.

As Liberia emerges from conflict and rebuilds its forestry and agricultural sectors, the fate of forested landscapes such as those in the greater Sapo area is a great cause for concern. To exploit its rich natural resources, this area has been divided up into new commercial concessions for mining, and the production of timber, oil palm and rubber. While the government of Liberia has committed ten percent of timber profits to conservation and the establishment of a protected area network through the reform of its forestry sector, fundamental concerns have arisen directly relating to the revenue generated for conservation (SDI 2010, Global Witness 2012). Since 2010, for example, there has been a sharp rise in the issuance of Private Use Permits, which allow lower tax contributions to the government than do commercial contracts (Forest Management Contracts and Timber Sale Contracts). The establishment of commercial concessions that may overlap Sapo NP or its buffer zone, such as that of the Golden Veroleum oil palm company (Fricke 2010), further questions whether the political will is present in Liberia to take on the challenge and responsibility of protecting these unique and biologically diverse forests. With just one national park currently gazetted and considering the uncertainty regarding the future development of a protected area network, it is critical to study the status of mammals in commercial concessions in order to understand conservation priorities within them and devise plans to minimise impacts on mammalian diversity.

This particular survey, commissioned by Putu Iron Ore Mining (PIOM), was conducted in 2010–2011. It was part of a larger study documenting the presence of all large mammal species across the concession area to gain information on their relative abundance and distribution, to assess the significance of the site to these animals and to assess the likely impact of iron-ore exploration and planned open-pit mining on their populations. The present report documents the small carnivore fauna of the Putu Range, southeast Liberia.

Study Site

Located north of Sapo NP, the Putu Range in Grand Gedeh County constitutes the only significant mountainous area in southeast Liberia. It is thought to harbour unique habitats and microhabitats not found in surrounding lowland areas. It is composed of two mountain ridges (Mt Ghi in the west and Mt Jideh in the east) running north-north-east to south-south-west, that reach a maximum elevation of just under 800 m a.s.l. on Mt Jideh. Because of its importance to the integrity of Sapo NP, the Putu Range was originally proposed as part of an extension area to the park. However, reflecting long-term commercial mining interest in the site, it was eventually excluded when the park was extended in 2003. In 2005, an exploration licence covering the Putu Range in a concession area of 425 km^2 (within 5°33′49″–47′22″N, 8°05′48″–16′40″W) was awarded to PIOM. Exploration intensified from December 2008 and continues at the present time.

The vegetation on Mt Jideh, where open-pit mining is planned, is probably the most botanically rich inside the concession. Although it is thought that clear-felling was conducted along its ridgeline about a century ago, it is largely composed of mature forest and the climate along the ridgeline and the summit has submontane affinities. The ridgeline of Mt Ghi, which was logged in recent decades, is composed of secondary forest, with a thick understorey in parts. Large gaps occur where some of the relatively few remaining large trees have fallen during windstorms. Most of the slopes are, however, composed of intact mature forest.

Lowlands in the PIOM concession comprise a mosaic of different habitats and transitional habitat types, in part consequential to commercial logging and the 14-year civil conflict (1989–2003) that saw fluctuations in the migratory and distribution patterns of the local human population. Recolonising secondary forest, disturbed swamp forest and large cleared areas of fallow farmland and/or Marantaceae fields with little canopy cover, occur. Lowland forest between the mountain ridges and west of Mt Ghi has regenerated and although patches of mature forest and large trees are rare, there is minimal disturbance. In contrast, the forest east of Mt Jideh, where the human population is largely concentrated along the motor-road, is highly disturbed and degraded.

Anthropogenic pressure in the form of hunting and artisanal gold mining by local people is of concern in the concession. In recent times both have intensified and represent a significant threat to mammal diversity in the area, with some gold mining camps supporting several hundred people. Gun-hunters tend to target large-bodied mammals, such as primates and ungulates, for commercial trade within Liberia, because of the higher income these animals generate (Greengrass 2011). Small carnivores, such as mongooses and African Civets *Civettictis civetta*, are caught in snares, which are often set in areas of cultivation. While the meat of these species is not usually sold, their commercial importance may rise in the future, given that present levels of harvesting of large-bodied mammals are potentially unsustainable.

Up to five different species of mongooses (Herpestidae), the Honey Badger (Ratel) *Mellivora capensis* (Mustelidae) and three or more species of civets and genets (Viverridae) are thought to inhabit the Putu Range. Two species of otter (Mustelidae: Lutrinae), the African Clawless Otter *Aonyx capensis* and the Spotted-necked Otter *Lutra maculicollis*, are also thought to occur, but are not considered here: the survey focused on land habitats, with the main waterways insufficiently sampled.

Methods

Camera-traps were used because they are widely employed to survey elusive and nocturnal species, as well as those occurring at extremely low density (e.g. Carbone *et al*. 2001, Henschel 2008). A detection versus non-detection camera-trapping study was conducted between November 2010 and May 2011. Seven Cuddeback Capture 3.0 megapixel camera-traps and seven Camtrakker MK-12 camera-traps were initially deployed for a pilot study in November and December 2010. Later, 10 more Cuddeback camera-traps were added. Initially, some camera-traps were set with a lure, but the lure seemed to attract only African Civet so its use was discontinued. Cameras were set opportunistically near large fruiting trees, well-defined animal paths and stream banks, typically about 30 cm above the ground. They were set to operate throughout the 24-hr cycle. Cameras were set opportunistically near large fruiting trees, well-defined animal paths and stream banks. Up to six cameras were set on the same day along or in the vicinity of a particular reconnaissance search area and then retrieved after a period of time that varied from 10 to 30 days. The distance between cameras so grouped varied widely from a few meters to several kilometers. Camera-trap survey effort totalled 1,591 trap-days/nights. Camera-traps were placed in 18 clusters in four of the five main geographical areas inside the concession (Fig. 1). These were: i) the Eastern Lowlands that lie to the east of Mt Jideh and continue eastwards across the main motor-road where most villages are concentrated; ii) Mt Jideh, the largest and most easterly lying mountain which includes Mt Montroh that is an east–west trending extension of the northern end of Jideh; iii) the Central Valley, a large, extensive valley that lies between Mt Jideh and Mt Ghi; and iv) Mt Ghi, the most westerly lying mountain ridge that rises to an elevation of about 600 m a.s.l. Reflecting time constraints, the Western Lowlands, which are significantly more rugged than the Eastern Lowlands and less accessible to the local human

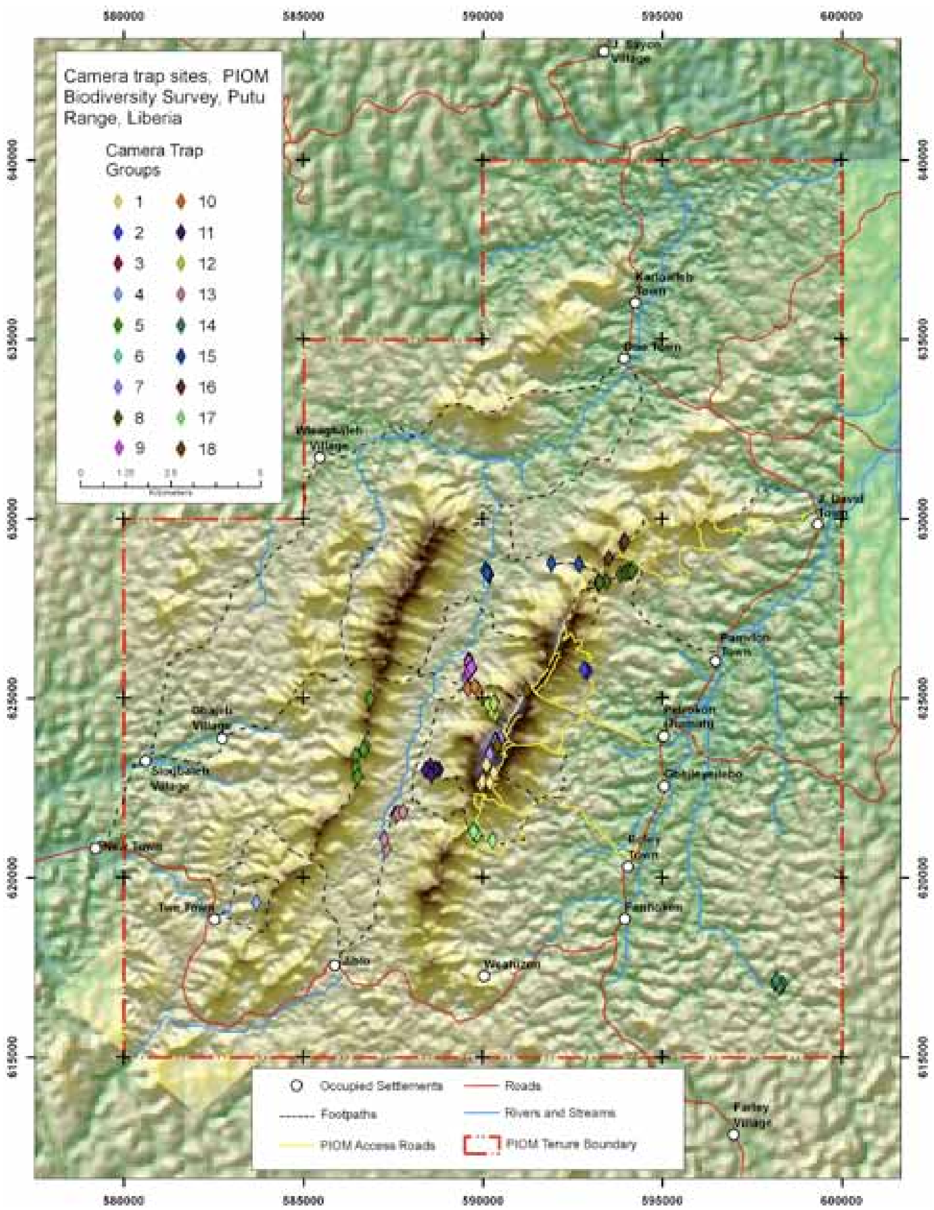

Fig. 1. Camera-trap locations inside the Putu Iron Ore Mining concession, Liberia. Grid: Universal Transverse Mercator zone 29.

population, were not surveyed with camera-traps. By the end of the survey, most camera-trap survey effort focused on Mt Jideh and the Central Valley; the former because it represented the site most likely to have been negatively affected by exploration activities and potentially most likely to be threatened by mining (see Table 1), the latter because it was close to the proposed mine area and was initially considered as a possible location for a mine waste dump.

A broad area reconnaissance using, in the most part, existing paths and tracks, was implemented to record encounter rates of mammals (e.g. number of animal signs per unit distance). Two people conducted those surveys: the author (EJG) and an ex-hunter guide (J. Cheflar) who had specialised knowledge of animal signs. Most reconnaissance searches (in short: 'recces') started between 06h30 and 07h00, to maximise direct encounters with diurnal mammals. Recces involved walking quietly through the forest at 1–2 km/h, on the predetermined survey routes and recording all encounters (direct sightings, faeces, prints, vocalisations, etc.) of large and medium-sized mammals. All recce survey data were collected using a durable hand-held computer, a Personal Digital Assistant (Trimble Nomad 800 L) with Cybertracker software specially tailored to the type of data collected in the field. The Trimble Nomad had an inbuilt GPS and tracklog capability and Cybertracker software can use these data to determine dis-

Table 1. Survey coverage of the Putu Iron Ore Mining concession, Liberia.

Geographical area	Total number of recces	Total distance covered (km)	Camera-trap effort (trap-days)
Eastern Lowlands	3	10.28	75
Mt Jideh	9	22.64	662
Central Valley	3	22.54	662
Mt Ghi	5	25.88	192
Western Lowlands	3	18.69	0

tances walked and calculate encounter rates. However, these calculations proved inaccurate and because the distances were previously calculated using a Garmin GPSMAP 60CSx, encounter rates were calculated by hand. Data collected in the field were regularly downloaded into Cybertracker on a laptop computer.

The survey design, established during a preliminary investigation of the site in October and November 2010, comprised 23 recces (each of 1.22–10.61 km in length) covering a total distance of 100 km (see Fig. 2; recce 23 & 24 were subsequently walked as one recce). Approximately half of the total survey distance covered the two prominent mountain ridges. Each recce covered just one of the five geographical areas inside the concession but all geographical areas were covered (see Table 1). All but one of the recces were walked three times between December 2010 and April 2011. One recce was walked twice in December 2010 and January 2011.

Results

Mongooses (Herpestidae)

The survey confirmed the presence of three species of mongooses, all listed as Least Concern (IUCN 2012): Common Slender Mongoose *Herpestes sanguineus*, Marsh Mongoose *Atilax paludinosus* and Common Cusimanse *Crossarchus obscurus*.

Slender Mongoose was recorded in disturbed areas: it was occasionally and opportunistically sighted running across the main motor-road in the Eastern lowlands and across the PIOM roads on Mt Jideh during daylight hours. It was recorded once on a camera-trap in a fallow farm in the Eastern Lowlands, east of the village of Pennekon (see Fig. 1). It was never observed during the recce survey, which was mostly in closed-canopy forest.

Marsh Mongoose was camera-trapped 14 times, in six different locations, suggesting a wider distribution and larger numbers than other species of mongooses. Images – including those of

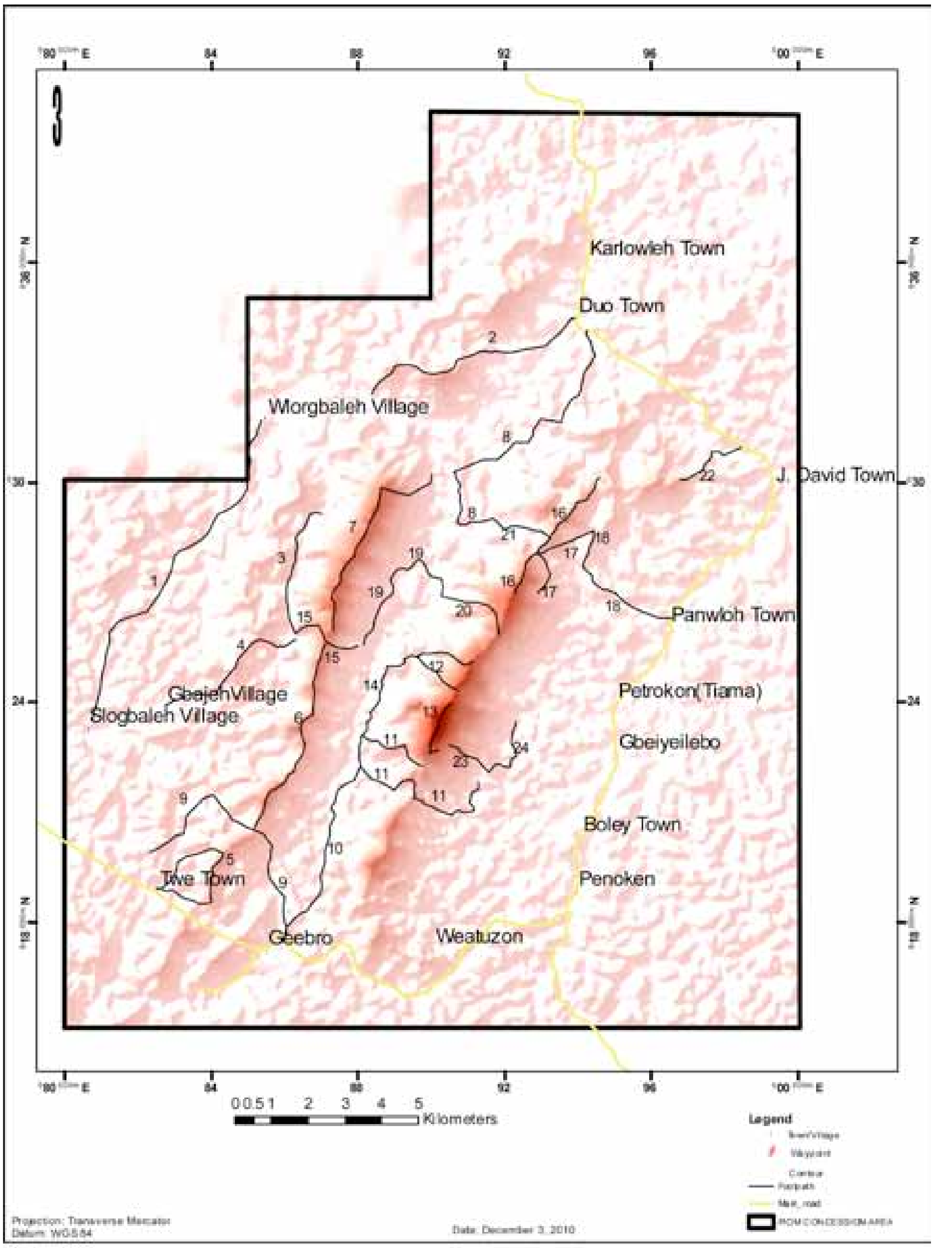

Fig. 2. Reconnaissance survey design inside the Putu Iron Ore Mining concession, Liberia. Grid: Universal Transverse Mercator zone 29.

young – were captured in a variety of habitat types: in closed-canopy forest on the mountain ridges, in farm bush and along PIOM roads on Mt Jideh, in areas that were being actively explored.

Common Cusimanse was the only small carnivore sighted during the recce survey. In December 2010, groups of Cusimanses were observed three times in closed-canopy forest on Mt Jideh and Mt Ghi; two encounters (on recce 7 and recce 17; Fig. 2) were of two individuals. This species was not encountered again until May 2011, when a group of about 10 was observed on the lower western slope of Mt Jideh. Cusimanse was once camera-trapped: on Mt Jideh during December 2010.

Badgers and allies (Mustelidae)

Honey Badger was confirmed by camera-trapping at only one location – a den site – on the eastern slope of Mt Jideh, in closed-canopy forest close to a stream. This specific site was chosen after the author encountered the burrow by chance (Fig. 3), and shone a torch down it. This elicited a series of fierce rattling growls, which is typical defensive behaviour of Honey Badger. Forest-dwelling individuals in Central Africa have been reported as being all black (Hunter & Barrett 2011, Bahaa-el-din *et al*. 2013): this was apparent in the images (Fig. 4).

Fig. 3. Honey Badger *Mellivora capensis* den, Putu Iron Ore Mining concession, Liberia.

Fig. 4. Honey Badger *Mellivora capensis* social behaviour (olfactory communication), Putu Iron Ore Mining concession, Liberia.

Twenty-six images were captured of these animals near the den between December 2010 and April 2011. Fifteen of the 26 images were taken after 06h00 hours and two images were taken after 09h00 (with the latest image recorded at 10h40). No activity was recorded again until after 17h00. Most images showed single individuals but three were of two. Five cases where single individuals were photographed were each followed within 30 minutes by another image of what was suspected, from size and appearance, to be a different individual, suggesting that these individuals were in association. A study of the images suggested that one relatively large adult male and two other adults were regularly using the den site. One of these adults was markedly smaller than the male and had a faint white patch or mantle on the top of its head. Because no male genitalia were captured on the images of this individual, it was presumably an adult female or possibly a sub-adult of either sex. The sex of the third adult could not be proposed. It was not possible to verify whether all images were of these three individuals, or whether additional individuals were using the den site. Other images showed African Brush-tailed Porcupine *Atherurus africanus* and bats using the den on days when the Honey Badgers were not photographed, so were presumed absent.

African Palm Civet (Nandiniidae)

Reflecting its nocturnal and arboreal nature, African Palm Civet *Nandinia binotata* was neither encountered on the recce survey nor camera-trapped. However, its species-typical vocalisation was heard in the forest at night, while the survey team camped within the concession, in areas of mature or re-colonising forest. In 2010, a dead, shot, individual was observed by the author in a village near the southern border of the concession, offered for roadside sale.

Civets and genets (Viverridae)

Occasionally, African Civet was seen on the PIOM roads at night. Its footprints (n = 30), however, were the most common small carnivore sign, and were regularly observed along these roads. While most footprints were observed in the Eastern Lowlands (n = 13) and Mt Jideh (n = 13), this was probably because of the predominance of roads there, rather than a natural preference for those areas. Thirty images at nine sites were recorded in all areas camera-trapped, suggesting that this species is widespread and common.

While arboreal in nature, genets may forage on the ground at night and occasionally small cat-like prints were encountered along roads. Only one species of genet, Bourlon's Genet *Genetta bourloni*, was identified from camera-trap images (P. Gaubert verbally 2011): the four confirmed images (e.g. Fig. 5) are believed to be the first photographs of wild-living individuals of this species. These images came from the PIOM ridgeline road on Mt Jideh in areas disturbed by mining exploration, on its western slope, in the Central Valley and on the ridgeline of Mt Ghi (Table 2). The species may thus be widely distributed at the site.

Discussion

In total, seven small carnivore species, representing four families, Viverridae (two species), Herpestidae (three species), Mustelidae

Table 2. Locations of Bourlon's Genet *Genetta bourloni* records, Putu Iron Ore Mining concession, Liberia.

Geographical area	Recce	Location	Date	Time
*Jideh western slope	12	5°20′22.959″N, 7°52′21.866″W	8 December 2010	08h37
Ghi ridgeline	6	5°18′18.828″N, 7°53′29.887″W	25 January 2011	06h13
Jideh PIOM road	11	5°20′06.927″N, 7°54′21.379″W	3 May 2011	05h11
Jideh PIOM ridgeline road	N/A	5°20′52.081″N, 7°52′11.125″W	5 May 2011	01h26
Central Valley	10	5°19′47.413″N, 7°53′39.735″W	24 May 2011	02h56

*Image of genet unidentified to species

Fig. 5. Bourlon's Genet *Genetta bourloni*, Putu Iron Ore Mining concession, Liberia.

(one species) and Nandiniidae (one species), were identified. Of particular note, the PIOM concession supports a population of the poorly-known, newly-described Bourlon's Genet: camera-trapping produced the first known images of wild-living individuals.

Moderate habitat disturbance may have a positive effect on some small carnivores such as mongooses, most of which are habitat generalists, such that some species are more abundant in rainforest fragments than in contiguous rainforest (Ray & Sunquist 2001). Slender Mongoose appears especially well adapted to disturbed and altered habitats. In West Africa, it is often observed in forest/cultivation mosaics and in oil palm concessions, and when crossing roads (EJG pers. obs.). Although Marsh Mongoose has a more selective diet (e.g. Ray & Sunquist 2001) it is also solitary, so may be better adapted to anthropogenic pressure than are more social species. It was camera-trapped both in disturbed habitats and in closed-canopy forest.

In contrast, Cusimanse is social and diurnal. Some (e.g. Davies 1990, Djagoun & Gaubert 2009) suggested it persists in a variety of habitats including farm bush, but others (e.g. Kingdon 1997) described it as largely restricted to lowland rainforest. In the PIOM concession, it was recorded only in closed-canopy forest.

Liberian Mongoose was not proven to occur. However, according to J. Cheflar, a mongoose matching its description was occasionally observed throughout the PIOM concession. These verbal reports suggest that even in the recent past, it was scarce in the study area. Its diet may be almost exclusively earthworms and insect larvae (Goldman & Taylor 1990), so lack of earthworms may exclude it from areas with hard laterite soils (Kingdon 1997), such as Mt Jideh. However, very little is known about this species. If it is a rainforest specialist, forest conversion and degradation in the site's lowlands over past decades may have driven a population decline. Its presence in nearby Sapo NP during concurrent camera-trapping (Vogt *et al*. 2012) supports this suggestion, because Sapo NP has never been logged or legally commercially exploited. The status of Liberian Mongoose in the Putu Range has yet to be adequately assessed; it was camea-trapped in Sapo NP only after a survey effort of 4,500 camera-trap-days (Vogt *et al*. 2012), three times the effort invested into the present survey. The sites being contiguous, this mongoose may well occur in the Putu Range but as Liberia commercially exploits more of its forest, Sapo NP probably represents the only foreseeable hope for the species's survival in the absence of other protected areas and in light of its declining range (Taylor 1989).

Liberian Mongoose and Cusimanse, taxonomically related, share the same name in the local Krahn language, qualified by references to colour and to Liberian Mongoose's distinctive neck stripe. The same Krahn name is also given to a third kind of animal, stated to differ only in colour from Cusimanse. Colour variants in other mongoose species are known or suspected (e.g. Ross *et al*. 2012), so this local name potentially signifies a so-far undocumented colour morph.

No evidence of Gambian Mongoose *Mungos gambianus* was recorded. In common with most social species, except cusimanses and Liberian Mongoose, it lives in open habitats (Veron *et al*. 2004). Local knowledge suggests that it indeed does not occur here, but may be present further south in Sinoe County.

Although using a range of habitats, Honey Badger was not thought to inhabit rainforest until recently (e.g. Hoppe-Dominik 1990, Hancox 1992) and little is known about its status, behaviour and life-history in such habitat. Globally, Honey Badger populations are decreasing (IUCN 2012), so forest-dwelling populations may be of particular importance. Described as 'campers' with no fixed den site (Vanderhaar & Hwang 2003), multiple camera-trap photographs showed what were possibly the same individuals returning to a deep underground den over several months. Moreover, local hunters knew of this den site, suggesting long-term use. Thus, forest Honey Badgers may have traditional den sites, albeit using them intermittently.

Honey Badgers are typically nocturno-crepuscular, with increased daylight activity in cold weather (Hunter & Barrett 2011). These forest-dwelling individuals' morning activity may reflect forest habitats' greater cover and lower daytime temperatures than those in the more open habitats where this species has mostly been studied.

Honey Badgers were not recorded in any other region surveyed with camera-traps, although a lack of records does not imply absence. They may naturally occur at low density: they are solitary or pair-bonded foragers with extremely large overlapping ranges, and have low fecundity because of a long inter-birth interval and small litter size (Begg *et al*. 2005a, 2005b). However, the frequent use of this den by the individuals that used it suggests that suitable den sites may limit this species's distribution in forests. It is not known to what extent commercial bushmeat hunting has reduced its population. It is rarely hunted, in part because it occurs at low density, but also because it is considered especially aggressive (the Liberian English name for a Honey Badger is a 'wolf'). Future mining of Mt Jideh may be detrimental to the local population, because this den site will be destroyed.

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Distribution, habitat use and activity patterns of nocturnal small carnivores in the North Luangwa Valley, Zambia

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Abstract

Surveys of the diversity, distribution, habitat use and nocturnal activity patterns of small carnivores were conducted in a protected part of the North Luangwa Valley, Zambia, during three periods: dry season (September–November) 2003; dry season (September–November) 2004; and wet season (May–June) 2005. The first used direct-observation and camera-trap surveys across seven habitats, whereas the second and third took place in two forest habitats and used only camera-traps. Camera-traps were set over scented lures and operated nightly, during 17h30–05h30. In the first season, observations of animals were made while driving along 2,500 km (100 daylight hours) and 150 km (8 night-time hours) of dirt track. These first-period surveys detected 13 carnivore species. The camera-traps operated for 690 trap-nights exposing 315 frames, 62% of which contained an animal. Of the animals photographed (n = 194), 68% (n = 131) were carnivores, of 11 species in five families: Mustelidae, Herpestidae, Hyaenidae, Viverridae and Felidae. Viverrids accounted for nearly half (46%) of carnivores photographed, followed by mongooses (35%), hyaenas (13%), mustelids (4%) and cats (2%). No species of Canidae were camera-trapped, despite their confirmed occurrence in the area. Extreme daytime temperatures constrained camera-sensor operation to nights; thus, diurnal species were under-recorded. Species-specific differences observed in visitation times between habitats suggest differences in species activity patterns. During the second and third survey periods combined, camera-traps recorded 674 photographs of five carnivore species in the two forest habitats: mongooses (Bushy-tailed Mongoose *Bdeogale crassicauda* and Meller's Mongoose *Rhynchogale melleri*) were photographed most often (83%), followed by viverrids (genets *Genetta*, 9%; African Civet *Civettictis civetta*, 7%) and mustelids (Ratel *Mellivora capensis*, <1%). Within the two forest habitats, carnivore distribution, and both the timing and amount of visitation, varied by season. The highest visitation levels were in Hill Miombo in the wet season. The changing visitation rates through the night suggest that spotlighting (a popular nocturnal carnivore survey method, rarely conducted uniformly through the night) may bias detection and thus status assessments for some species.

Keywords: *Bdeogale crassicauda*, camera-trap, *Genetta*, Herpestidae, miombo woodland, *Rhynchogale melleri*, Viverridae, wildlife survey

Distribution, utilisation de l'habitat et patrons d'activité des petits carnivores nocturnes dans la Vallée de Luangwa Nord, en Zambie

Résumé

La diversité, la distribution, l'utilisation de l'habitat et les patrons nocturnes d'activité des petits carnivores ont été étudiés dans une partie protégée de la Vallée de Luangwa Nord, en Zambie, lors de trois périodes: 1) saison sèche (septembre–novembre) 2003, 2) saison sèche (septembre–novembre) 2004, et 3) saison humide (mai–juin) 2005. Durant la première saison, l'étude a été menée dans sept types d'habitats et était basée sur l'observation directe et l'utilisation de pièges photographiques, alors que pendant les deuxième et troisième saisons seuls des pièges-photos ont été utilisés dans deux habitats forestiers. Les appareils photographiques, associés à des leurres odorants, opéraient chaque nuit de 17h30–05h30. Durant la première saison, des observations directes d'animaux ont été faites lors d'inventaires effectués en voiture le long de 2'500 km (100 heures à la lumière du jour) et 150 km (8 heures pendant la nuit) de pistes en terre. L'étude a permis de détecter 13 espèces de carnivores. Les pièges-photos ont opéré durant l'équivalent de 690 nuits de piégeage, fournissant 315 clichés dont 62% d'entre eux contenaient un animal. Des animaux photographiés (n = 194), 68% (n = 131) étaient des carnivores appartenant à 11 espèces réparties en cinq familles taxonomiques: Mustelidae, Herpestidae, Hyaenidae, Viverridae, Felidae. Les viverridés représentaient presque la moitié (46%) de tous les carnivores photographiés, suivis par les mangoustes (35%), les hyènes (13%), les mustélidés (4%) et les félins (2%). Aucun canidé n'a été photographié malgré la confirmation de leur présence dans la zone d'étude. En raison des températures extrêmes durant la journée, le fonctionnement du senseur des appareils photographiques a été restreint aux périodes nocturnes, si bien que les espèces diurnes étaient sous-représentées. Les différences observées au niveau de l'heure des visites des pièges-photos suggèrent des différences interspécifiques dans les patrons d'activité. Lors des seconde et troisième périodes d'études combinées, les pièges-photos ont permis d'obtenir 674 photographies de cinq espèces de carnivores dans les deux habitats forestiers. Les mangoustes (Mangouste à queue touffue *Bdeogale crassicauda* et Mangouste de Meller *Rhynchogale melleri*) ont été photographiés le plus souvent (83%), suivis par les viverridés (genettes *Genetta*, 9%), Civette africaine *Civettictis civetta*, 7%) et les mustélidés (Ratel *Mellivora capensis*, <1%). A l'intérieur des deux habitats forestiers, la distribution des carnivores ainsi que l'heure d'occurence et le nombre de visites ont varié de manière saisonnière. Les niveaux de visite les plus élevés ont été observés dans le miombo collinéen durant la saison humide. Les variations dans les taux de visite durant la nuit suggèrent que les études nocturnes au phare (une méthode populaire pour recenser les carnivores nocturnes rarement conduite de façon uniforme durant la nuit) peuvent biaiser la détection et ainsi les évaluations du statut de certaines espèces.

Mots clés: *Bdeogale crassicauda*, forêt de miombo, *Genetta*, inventaire faunistique, mangoustes, piège-photographique, *Rhynchogale melleri*, viverridés

Introduction

Many African small carnivore species are inconspicuous nocturnal forest dwellers (Ewer 1973, Smithers 1983) that are difficult to detect: as a consequence, little is known about them. Nevertheless, forest carnivores are of interest both from an academic standpoint and in light of global trends prioritising resource extraction and use without adequate consideration of environmental impacts (Greene 1988). It is often assumed that by virtue of their size, small carnivores are less prone to direct persecution than are the larger species. However, illegal trade in bush meat and skins (e.g. Colyn *et al*. 1988, Ray *et al*. 2002, Golden 2009, Shepherd & Shepherd 2010, Dolch 2011), land conversion and deforestation are all current threats to at least some small African carnivore species (Crooks 2002, Kauffman *et al*. 2007, Dunham & Gaubert 2008). The extent to which human practices threaten regional populations of small carnivores is only beginning to be investigated (Colón 2002, Crooks 2002, Azlan 2003, Kauffman *et al*. 2007, Cheyne *et al*. 2010a, Mathai *et al*. 2010, Wilting *et al*. 2010). The paucity of baseline data about many small carnivore species hinders assessment of impacts and development of appropriate conservation strategies (Greene 1988, Ray *et al*. 2002).

Camera-traps are growing in popularity as an invaluable tool for detecting secretive species (e.g. Foresman & Pearson 1998, Cutler & Swann 1999), replacing more invasive types of research such as radio-collaring. Increasingly, camera-traps are documenting first records of little-known carnivores in little-known ecosystems (Brink *et al*. 2002, Goldman & Winther-Hansen 2003, Rovero *et al*. 2006, Charoo *et al*. 2010, Cheyne *et al*. 2010b, Jenks *et al*. 2010, Moqanaki *et al*. 2010), and may clarify species abundance (Gerber *et al*. 2010). For example, Bushy-tailed Mongoose *Bdeogale crassicauda*, a species previously considered rare (Taylor 1987), was among the most frequently camera-trapped species at several localities in Tanzania's Eastern Arc Mountains (De Luca & Mpunga 2005). Camera-traps can also be used to identify individuals (Karanth & Nichols 1998, Sequin Larrucea *et al*. 2007), and to quantify activity patterns (Sequin Larrucea *et al*. 2007) or behaviour (Picman & Schriml 1994). For species about which almost nothing is known, even short-term camera-trapping studies (Charoo *et al*. 2010, Cheyne *et al*. 2010b) or data accrued incidentally (González-Maya *et al*. 2009) can contribute significant insight concerning group size, activity pattern, habitat use and geographic range.

Zambia's Luangwa Valley has a high species richness (Pomeroy 1993, Barnes 1998, BirdLife International 2000, WWF-SARPO 2003) and lies adjacent to areas of known high species endemism, e.g. Bangweulu swamp (Zambia), Nyika plateau (Malawi), the Southern Highlands (Tanzania) and the Albertine Rift (Democratic Republic of Congo) (White 1983). As a transverse offshoot of the greater African Rift Valley system, the Luangwa Valley is known to contain many endemic forms (Ansell 1960, 1978). Twenty-two species of carnivores have been reported from this region (Table 1), within six families: dogs (Canidae), mustelids (Mustelidae), mongooses (Herpestidae), hyaenas (Hyaenidae), civets and genets (Viverridae) and cats (Felidae) (Kingdon 1977, 1997, Ansell 1978, Skinner & Smithers 1990).

The Luangwa Valley is experiencing rapid human population growth and rural expansion (Chenje & Johnson 1994) resulting in environmental change (Stuart *et al*. 1990, Dalal-Clayton & Child 2003, WWF-SARPO 2003). Apart from a few studies that focused on larger species (Yamazaki 1996, Yamazaki & Bwalya 1999, Anderson *et al*. 2011), the ecology of Luangwa Valley's small carnivore community is unknown. The Luangwa Valley is just one of many areas in Africa lacking a long-term monitoring programme focused on small carnivore conservation. The present study therefore surveyed carnivores by camera-traps and direct observations in the dry and wet seasons of 2003–2005. It took place in an area of protected, intact habitat with minimal human disturbance. Thus, its results provide a starting point for future studies, especially in other regions within and beyond the Luangwa Valley that are experiencing rapid human population growth, rural expansion and resultant anthropogenic change.

Methods

Study area

The study took place in the North Luangwa National Park (11°47′S, 32°10′E), Luangwa Valley, north-eastern Zambia, south-central Africa (Fig. 1). The Luangwa Valley is a transverse extension of the greater African Rift Valley system, bordered northwest by the Muchinga Escarpment and southeast by Malawi's Nyika Plateau. To the northeast lie Tanzania's Eastern Arc Mountains. The Luangwa River arises from the Mafinga Mountains at about 2,400 m a.s.l. It is fed by the perennial Mwaleshi River that originates in the Muchinga Escarpment, and by several other rivers that flow seasonally from the escarpment and plateau. The broad, silt-laden Luangwa River cuts a sandy swath through the Valley bottom on its way to join the Zambezi River in the south.

Vegetation throughout the region is predominantly Mopane *Colophospermum mopane* woodland and miombo *Brachystegia* woodland (MTENR 2005). On a more localised scale, different vegetation types occur patchily throughout the Luangwa Valley, especially in relation to elevational changes and topographic microclimates (Smith 1998) (Fig. 2).

During the single long rainy season from December to April, the Luangwa River reaches full flood. Using each month's average daily mean, the coolest temperatures (10 °C) occur in June and July, after the rains. From that point, temperatures rise steadily, peaking in October at 37 °C. Outlying water sources have dried up by that time, so herbivores and carnivores alike congregate along the rivers to await the onset of the rains in late November.

Sampling methodology

Part I. All surveys in 2003 were conducted during the dry season (September–November). Surveys consisted of direct searches for animals during daylight driving circuits and

Table 1. Number of camera-trap and direct-observation records of each carnivore species* in North Luangwa National Park, Zambia, during 2003–2005.

Species	**Number of records**			
	Direct observation (daytime)	**Direct observation (night-time)**	**Camera-trap Phase I**	**Camera-trap Phase II**
Canidae				
Side-striped Jackal *Canis adustus*	0	0	0	0
African Wild Dog *Lycaon pictus*	0	0	0	0
Mustelidae				
Honey Badger *Mellivora capensis*	0	0	5	2
African Clawless Otter *Aonyx capensis*	0	0	0	0
Herpestidae				
Egyptian Mongoose *Herpestes ichneumon*	0	0	0	0
Common Slender Mongoose *Herpestes sanguineus*	11	0	0	0
Common Dwarf Mongoose *Helogale parvula*	2	0	0	0
Banded Mongoose *Mungos mungo*	1	0	0	0
Marsh Mongoose *Atilax paludinosus*	0	0	0	0
White-tailed Mongoose *Ichneumia albicauda*	0	0	8	0
Meller's Mongoose *Rhynchogale melleri*	0	1	13	162
Bushy-tailed Mongoose *Bdeogale crassicauda*	0	0	21	287
Unidentified Meller's/Bushy-tailed Mongoose	0	0	3	114
Hyaenidae				
Spotted Hyaena *Crocuta crocuta*	2	5	17	0
Viverridae				
Genet *Genetta*	0	2	16	62
African Civet *Civettictis civetta*	0	0	45	47
Felidae				
Wild Cat *Felis sylvestris*	0	0	0	0
Serval *Felis serval*	0	0	0	0
Caracal *Felis caracal*	0	0	1	0
Leopard *Panthera pardus*	0	1	1	0
Lion *Panthera leo*	4	1	1	0
Cheetah *Acinonyx jubatus*	0	0	0	0
Total	**20**	**10**	**131**	**674**

*All species potentially present, based on historical information, are listed. Four genets are known from Zambia: Miombo Genet *G. angolensis*, South African Small-spotted Genet *G. felina*, Common Small-spotted Genet *G. genetta* and Rusty-spotted Genet *G. maculata* (Gaubert *et al*. 2005); the historical records from the Luangwa Valley, of 'Blotched Genet *Genetta tigrina*' and 'Servaline (or Pardine) Genet *Genetta servalina*', would need re-evaluation in the light of taxonomic and nomenclatural change.

night drives using spotlights (both at a speed of 25 km/hr), and camera-trapping at scented lures. Camera-trap stations were situated along transects in each of seven habitat types that spanned an elevational gradient from the Luangwa River in the Valley floor (600 m) to near the top of the Muchinga Escarpment (1,177 m). Seven habitats defined based on predominant vegetation type (Fig. 2) were surveyed: 1) Escarpment Forest (dry, evergreen), 2) Hill Miombo, 3) Wooded Grassland Mosaic, 4) Valley Riverine Complex (dry), 5) Valley Riverine Complex (perennial stream), 6) *Combretum–Terminalia* Woodland and 7) Secondary Annual Grassland (Fig. 1).

Part II. Two habitats (Escarpment Forest and Hill Miombo) were intensively camera-trapped during a three-month dry season (September–November 2004) and a two-month wet season (May–June 2005). The time- and date-stamped photographs were used to examine seasonal differences in species composition and visitation (activity) patterns within and between the two forest habitats.

Camera-trap stations

Camera-trap stations were located 10–50 m from roads, 0.5–1.0 km apart, and at least 1.0 km from transitions to other habitats. In Part I, ten camera-traps were set for 8–11 days along a transect within a homogenous habitat type, then moved to a new transect-line in a different habitat. During Part II, five camera-traps were operated at evenly spaced static locations in each of the two forested habitats for the entire dry (2004) and wet (2005) sampling period (Fig. 1). A 'trap-night' was the equivalent of one camera set for one night (i.e. a 12-hr period).

Each camera-trap station consisted of a remotely activated 35 mm instamatic camera with electronic flash (Trailmaster TM35-1) coupled to a motion/heat detector (Trailmaster TM550) (Trailmaster Inc., Lenexa, Kansas). The camera was set to be triggered by animals within 20 m and a 150° radius of the camera. In addition, a 5-min delay was set to avoid repeatedly photographing an individual lingering at a scent station. More than 85% of the time-consecutive photographs separated by 10 minutes or more contained different species. An

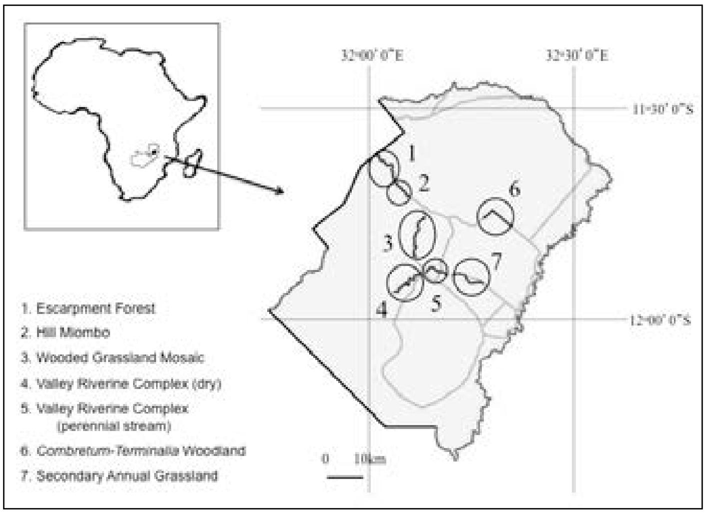

Fig. 1. North Luangwa National Park, Zambia, showing camera-trapping transect locations and associated habitat types. Park borders designated by irregular lines are rivers. Interior grey lines are dirt roads. Transects 1–7 were sampled during the dry season 2003. Transects 1–2 were resampled during the dry season 2004 and the wet season 2005.

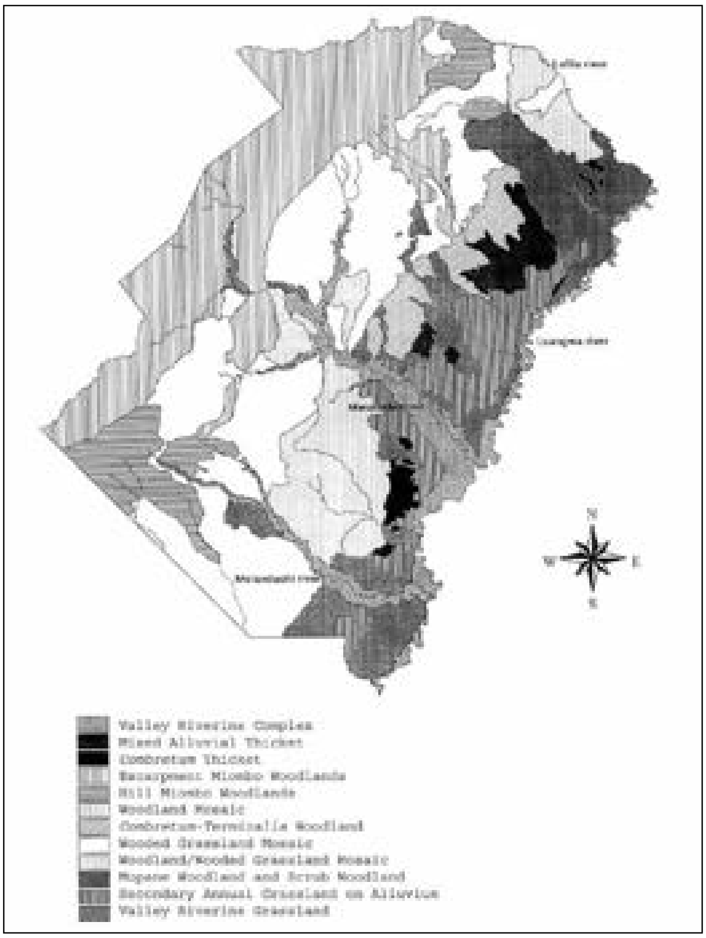

Fig. 2. Vegetation map of North Luangwa National Park, Zambia.

additional time of 5 minutes was added to create a 15-minute latency period between notionally independent 'visits'. Thus, a photograph of a species taken at least 15 minutes after the preceding one was counted as a new 'visit'.

Camera-trap systems were secured to trees at a height of 1.5 m and aimed towards a scent lure of minute amounts (<¼ teaspoon) of rotten meat juice and honey/jam juice applied with a spray bottle to a rock or tree-trunk at ground level. The lures produced a scent but did not constitute a significant amount of food even for a small carnivore, as evinced by the short (<10-min) duration of most visits. This combination of scents was selected in efforts to attract carnivorous, frugivorous and omnivorous species. Scents were refreshed daily. Cameras were checked each day around midday and film and batteries replaced as needed.

Exposed frames were examined, visitation times tallied, and animals identified to species when possible. Bushy-tailed Mongoose and Meller's Mongoose *Rhynchogale melleri* are similar enough on film as to hinder reliable distinction, so an 'unidentified mongoose' category was included when recording number of visits, and results of activity patterns for these mongoose species were combined. Similarly, four species of genet *Genetta* with relatively small external morphological differences inhabit Zambia (Table 1), so genet photographs were identified only to genus. Time-stamp photographs were used to analyse visitation times (activity patterns) by taxon.

Results

Part I. 2003 dry season

During the 2003 dry season, daylight driving surveys along 2,500 km of dirt track during 100 hours provided 20 direct observations of carnivores, and night-time surveys along 150 km of dirt track during 8 hours generated 10 observations. In total, eight species of carnivores were detected during driving surveys (Table 1).

Camera-traps were deployed along 65 km of roads and rivers through seven habitat types during 690 trap-nights (80–110 trap-nights per habitat) (Table 2). The total number of visits varied by habitat type (mean = 46 visitors per habitat, range 26–69) (Table 2). Escarpment Forest and Secondary Annual Grassland had the highest visitation, Valley Riverine Complex (dry) and *Combretum–Terminalia* Woodland the lowest. Of the 315 camera-trap photographs, 194 (62%) contained an animal. Of the animals photographed, 131 (68%) were carnivores, of 11 species.

Combined, all survey methods detected 13 carnivore species from five families (Tables 1–2). The remaining photographs (n = 63) featured non-carnivore species, most commonly Bush Duiker *Sylvicapra grimmia*, also Aardvark *Orycteropus afer*, African Elephant *Loxodonta africana*, Plains Zebra *Equus quagga*, Bush Pig *Potamochoerus larvatus*, Cape Buffalo *Syncerus caffer* and Impala *Aepyceros melampus*.

Dry season visitation patterns varied widely between habitat types, however two general patterns emerged (Fig. 3). Within the Escarpment Forest and Secondary Annual Grasslands, visitation was relatively uniform throughout the nocturnal hours with only minor peaks in activity in the early- and midnight hours, respectively. In contrast, within all other habitats sampled, highest levels of visitation occurred in the early evening, immediately or shortly after dark. Of the latter group, most showed a gradual tapering off over the course of the night, although a small secondary peak in activity just prior to

Table 2. Habitat features, camera-trapping effort and number of visits for each transect during Part I (dry season 2003) of this study in North Luangwa National Park, Zambia.

Transect	Habitat Type	Elevation range[1] (m)	Number of camera-trap-nights	Number of visits
1	Escarpment Forest	1,177–1,026	100	69
2	Hill Miombo	975–758	90	50
3	Wooded Grassland Mosaic	717–643	110	42
4	Valley Riverine Complex (dry)	640–629	80	26
5	Valley Riverine Complex (perennial stream)	636–608	100	43
6	*Combretum–Terminalia* Woodland	658–687	100	27
7	Secondary Annual Grassland	599–630	110	58

[1] The lowest and highest points in the transect.

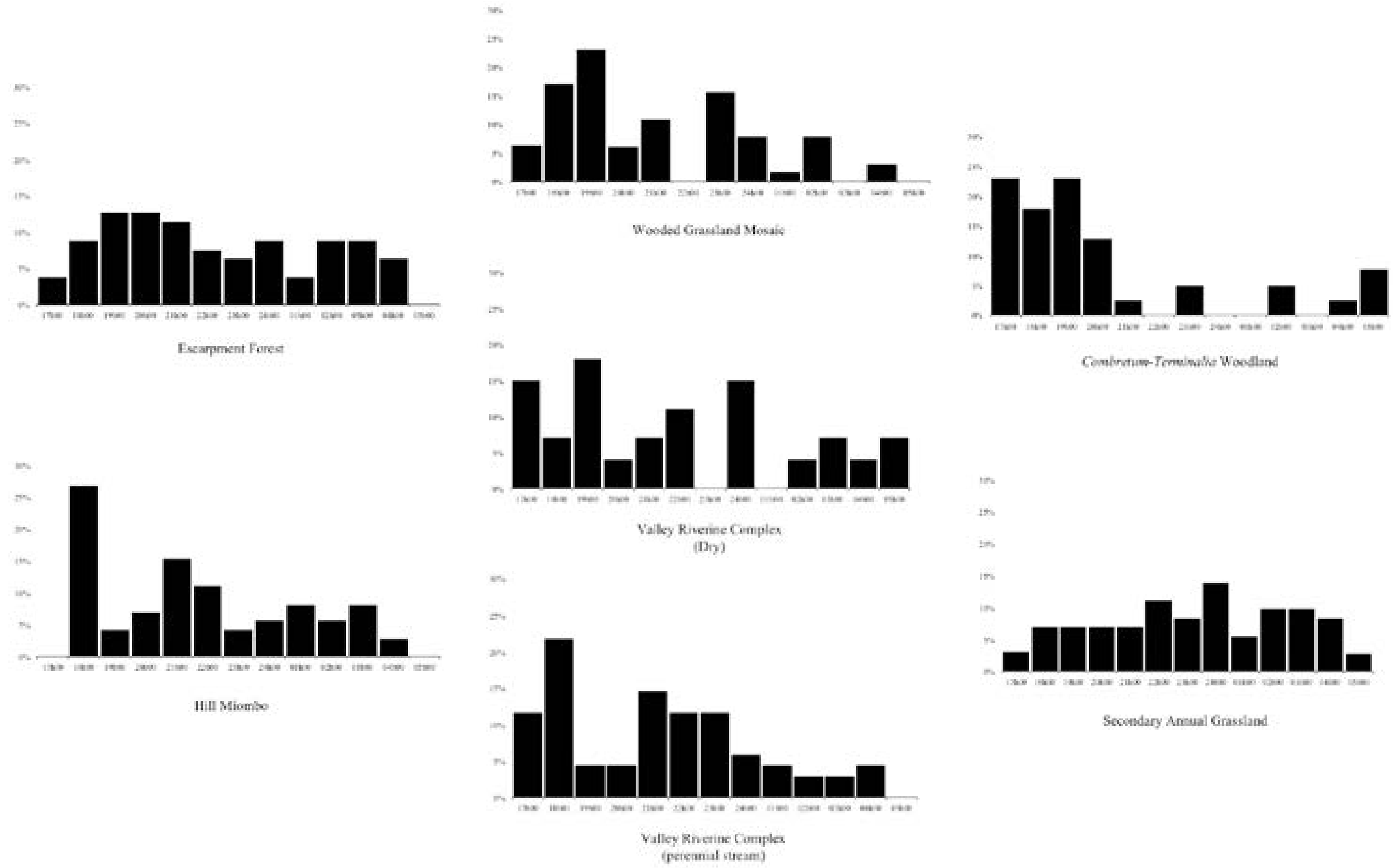

Fig. 3. Patterns of nocturnal carnivore visits to camera-trap stations in each of seven habitat types sampled during the dry season 2003 in North Luangwa National Park, Zambia. For each habitat, results shown are for all carnivore species combined.

dawn was not uncommon (Fig. 3). Differences in activity patterns were attributed to variable species composition among the different habitat types.

Part II. Species composition in two forest habitats

Of 392 visits recorded to the Escarpment Forest camera-traps, the most frequently photographed visitors were Meller's Mongoose and Bushy-tailed Mongoose combined (Table 3). These were also the most-photographed visitors in Hill Miombo. However, a larger percentage of the 282 total visits in Hill Miombo comprised other species, including genets and African Civet *Civettictis civetta* (Table 3). Genets were recorded more often in the wet season than in the dry, in the Hill Miombo 17× so, in the Escarpment Forest 2.5× so. Civets were photographed in both forest types during the dry season, but only in the Hill Miombo during the wet, where they were recorded 7× more often than during the dry. Ratels *Mellivora capensis* were detected very rarely in the Hill Miombo, and not at all in Escarpment Forest (Table 3).

Seasonal variation in visiting patterns

Within each of the two forest habitats, wet- and dry-season visiting patterns were compared (Fig. 4).

Meller's and Bushy-tailed Mongooses combined showed relatively uniform nocturnal visit patterns, becoming active shortly after dusk (18h00–19h00) and visiting often until tapering off just before dawn (Fig. 4). In both forest types, visits were much more frequent during the wet season than in the dry.

Table 3. Occurrence of small carnivores on photographs in each of two forest habitats in North Luangwa National Park, Zambia, dry season 2004 and wet season 2005.

Species	Number of visits			
	Escarpment Forest		Hill Miombo	
	Dry	Wet	Dry	Wet
Rhynchogale melleri	33	76	9	44
Bdeogale crassicauda	50	138	11	88
Unidentified *Rhynchogale/Bdeogale*	10	55	7	42
Genetta	7	18	2	35
Civettictis civetta	5	0	5	37
Mellivora capensis	0	0	1	1
Total	105	287	35	247

Additionally, during the wet season in Hill Miombo, mongooses showed a sharp peak in visits around 21h00 (Fig. 4).

Genets were active early in the evening, visiting already at dusk when camera-traps began operating, and continuing throughout the night. Visiting distinctly peaked at 20h00–21h00 and at 02h00–03h00. Genets made more visits in both habitats during the wet than in the dry season (Fig. 4). In both habitats, the largest peaks in visiting were consistently around 20h00 and 02h00, although during the wet season genets visited in the Hill Miombo during other times as well.

African Civet showed polymodal nocturnal visiting during the dry season, beginning only after total darkness (19h00–20h00) with secondary peaks at 00h00–01h00 and 03h00–04h00, tapering off abruptly in the hours before dawn. During the wet season, Civets visited earlier in the evening than in the dry season and visited throughout the night hours with the exception of a lull around 21h00 (Fig. 4).

All species showed the highest visitation levels in the Hill Miombo during the wet season, when they remained relatively active throughout the night. Throughout the year, both genets and African Civet showed nightly lulls following polymodal peaks of activity.

Discussion

Remote cameras proved effective in detecting nocturnal small carnivores in the Luangwa Valley, in particular viverrids and mongooses in densely vegetated habitats. Scent stations worked well to attract hyaenas and mustelids within camera range, but few pictures of cats, and none of canids were obtained. Methodology was similar across all habitats, thus potential biasing effects, e.g. camera-avoidance by species or individuals, or the effects of roads, were relatively constant. Overall, 60% of carnivore species previously reported from the region were detected by camera-traps and driving surveys combined over a 2-month dry season.

Time constraints on camera operation precluded detection

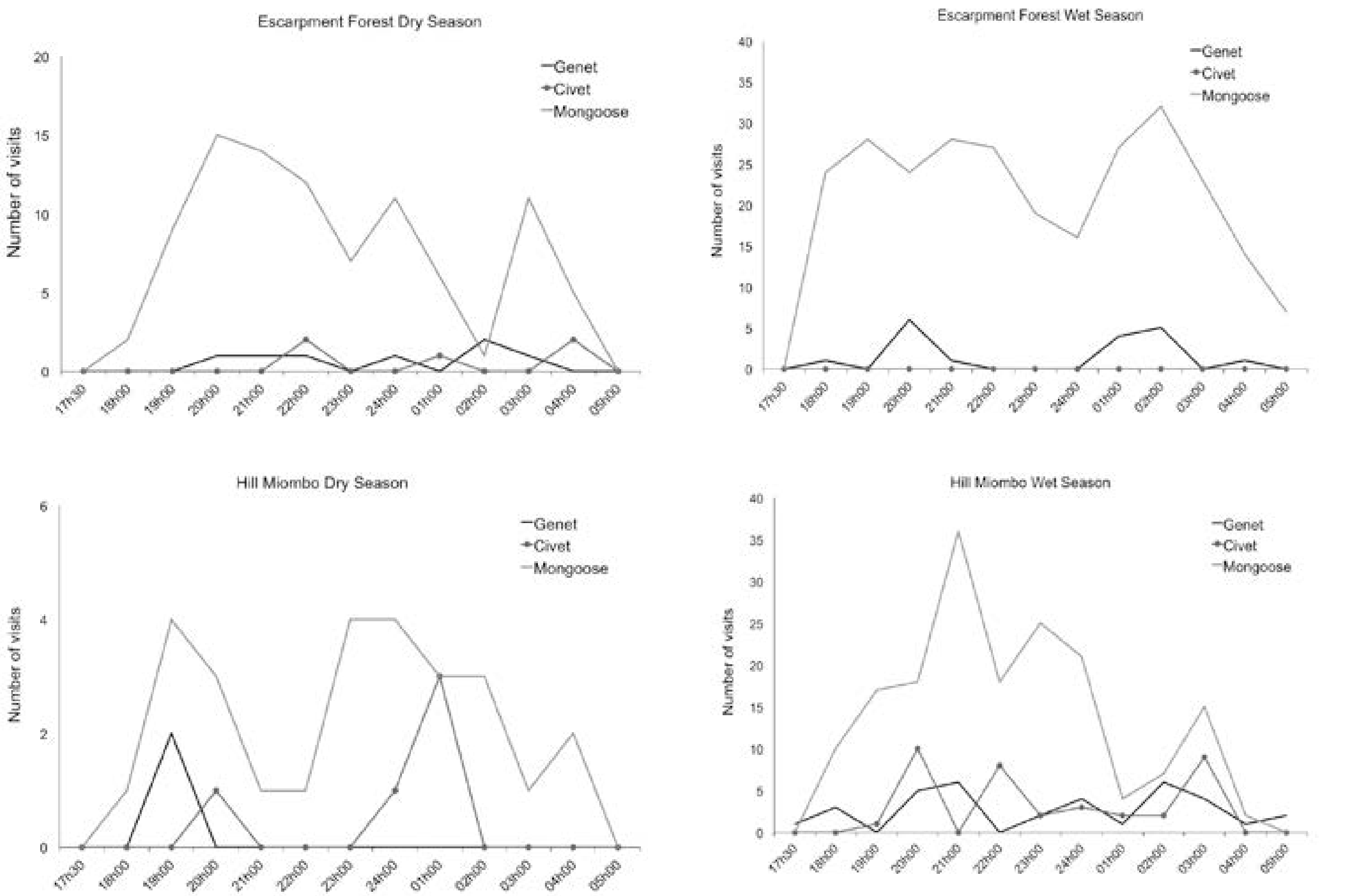

Fig. 4. Comparison of nocturnal visits to camera-traps during dry and wet seasons for all small carnivore species photographed within each of two forest habitats in North Luangwa National Park, Zambia.

of species active only by day. However, this does not explain the paucity of visits by larger ground-dwelling carnivores active at night, i.e. Lion *Panthera leo*, Leopard *Panthera pardus* and Side-striped Jackal *Canis adustus*. The Luangwa Valley holds about 500–600 Lions (PAW own data) and high densities of Leopards (Ansell 1960, Nowell & Jackson 1996). Cat presence was evidently not accurately represented by camera-traps, perhaps reflecting low appeal of the scents used. In contrast, African Wild Dogs *Lycaon pictus* are relatively few, and Side-striped Jackals have declined drastically over the past 30 years (A. Carr verbally 2005), so the lack of canid detections perhaps reflects their local rarity. The cause of Jackal decline is unknown. It might relate to disease transfer from Domestic Dogs *Canis familiaris*, which have increased dramatically in the Luangwa Valley during the past 10+ years (PAW own obs.).

Those species detected varied in the amount and pattern of visitation by habitat type. Camera stations were set >5 km from the nearest human dwellings, rendering activity patterns unlikely to be influenced by people as might be expected of small carnivores for example given the opportunity of scavenging on camp-site scraps. Excepting this study's night-surveys, park roads were closed to traffic after dark. Furthermore, scent lures were presented systematically, so any effects they may have had on carnivore visitation patterns should be uniform across all sampling stations. Differences in overall visitation patterns between habitats were attributed to species composition, although lunar phase may have also influenced predator movements (Waser 1980). Time-stamped photographs provided activity patterns for each species (for mongooses and genets, for aggregates of species). Consideration of species-specific activity times is important in designing spotlight surveys, because survey times may bias detection and abundance estimates if they are routinely conducted during a period of low activity for a particular species. However, activity patterns of partly arboreal and scansorial species may not be adequately represented when relying on camera-traps that detect ground-level movements.

Further dissection of mongoose and genet visitation data might detect differences in activity patterns between sympatric species. More detailed analyses of species activity times might lend evidence of temporal niche partitioning (Pianka 1969) as a mechanism reducing competition between the Luangwa Valley's sympatric carnivores. Temporal partitioning can facilitate coxistence among similar-sized sympatric carnivores (Ray 1997, Fedriani *et al*. 1999, Karanth & Sunquist 2000). However, Waser (1980) commented that overlap in both preferred vegetation types and foraging times within small nocturnal carnivore communities was not unusual. Likewise, the large overlaps of foraging times among the small carnivores inhabiting the Luangwa Valley's forests were possibly facilitated by the use of different types or sizes of prey (see Bothma *et al*. 1984, Sunquist *et al*. 1989, Karanth & Sunquist 2000, Walker *et al*. 2007).

Luangwa Valley's forests provide a year-round home to several species of nocturnal small carnivores, at least Bushy-tailed Mongoose, Meller's Mongoose, genets and African Civet. In the north of its range, Bushy-tailed Mongoose co-occurs with genets, White-tailed Mongoose *Ichneumia albicauda* and Zorilla *Ictonyx striatus* (Sale & Taylor 1970), in coastal forests with African Civet (Taylor 1986), and in Tanzania's Eastern Arc Mountains, with many nocturnal small carnivores including Marsh Mongoose *Atilax paludinosus*, Meller's Mongoose, Jackson's Mongoose *Bdeogale jacksoni*, White-tailed Mongoose, Servaline Genet *Genetta servalina*, Rusty-spotted Genet, Common Small-spotted Genet, African Civet, African Palm Civet *Nandinia binotata* and Ratel (De Luca & Mpunga 2005). The present study confirmed Bushy-tailed Mongoose co-occurrence with African Civet and genets in its western-central range, and is one of very few documented associations of it with Meller's Mongoose (see De Luca & Mpunga 2005).

While Bushy-tailed Mongoose was observed directly only once, it was among the most frequently photographed species in both the Escarpment Forest and Hill Miombo Forest communities. Similarly, it was the most frequently camera-trapped carnivore in the montane and lowland forests of Tanzania's Eastern Arc Mountains (De Luca & Mpunga 2005, Hoffman 2008), and uses a wide variety of other habitat types (Taylor 1987). The even lesser-known Meller's Mongoose is usually associated with woodland (Kingdon 1997), but has been photographed in montane bamboo forest and open wooded grassland in Tanzania at an altitude of 1,850 m (De Luca & Mpunga 2005). The present study recorded Meller's Mongoose in an altitudinal range of 750−1,175 m in Luangwa Valley, within that reported by Kingdon (1997).

Both Bushy-tailed and Meller's Mongooses are generally perceived as uncommon, yet in this study were frequently camera-trapped. This adds to the small carnivore conservation importance of Miombo Woodlands, which are among the earth's most biologically valuable and diverse ecoregions (Rodgers *et al*. 1996, Olson & Dinerstein 1998) with a plant community of particular importance to humans and other animals (Frost 1996, Barnes 1998, Williams *et al*. 2007, Munishi *et al*. 2010). Throughout Africa, Miombo Woodlands are heavily used for resource extraction by humans (Misana *et al*. 1996, Mapaure & Campbell 2002), but well-managed forests can support many small carnivores of many species (Wilting *et al*. 2010). Changes in carnivore community structure can have profound impacts on ecosystem dynamics (Terborgh 1988, Crooks & Soulé 1999), so studies examining species composition in relation to habitat perturbations help detect and document changes, and design regionally-effective conservation strategies (Kauffman *et al*. 2007, Mathai *et al*. 2010).

Future studies

Further analysis of this study's photographs will allow more positive identifications among similar-looking species (genets, and Bushy-tailed and Meller's Mongooses), and thus more detailed information on species within each sampled habitat. Re-evaluation of species-level visitation data may suggest differences in activity patterns that indicate temporal niche partitioning. This could help explain how similarly-sized mongooses and genets, respectively, reduce competition, especially during the dry season when resources are less abundant. GIS mapping of species locations will be used to analyse carnivores' microhabitat use. Camera-trapping throughout the 24-hr period would allow closer to complete documentation of the Luangwa Valley's small carnivore community. Surveying sites under different land-use regimes would clarify impacts of anthropogenic perturbations on the Luangwa Valley's carnivore species. For species with individually unique coat patterns (African Civet, genets, Spotted Hyaena), photographic capture–recapture may provide insights on short- and longer-term spatial-use patterns and on density. For species not individually recognisable, occupancy surveys (MacKenzie *et al*. 2002) can estimate abundance more reliably than 'Relative Abundance Indices', by incorporating detection probabilities (MacKenzie *et al*. 2002, Linkie *et al*. 2007, Ancrenaz *et al*. 2012).

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A preliminary survey of the presence and distribution of small carnivores in the Lower Zambezi Protected Area Complex, Zambia

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Abstract

An interview questionnaire survey of tour guides and game rangers in the Lower Zambezi National Park and Chiawa Game Management Area in south-eastern Zambia received credible reports of 15 small carnivore species of five taxonomic families (Canidae, Felidae, Herpestidae, Mustelidae and Viverridae). Two other species are considered likely to occur, and two more to be possible. Meller's Mongoose *Rhynchogale melleri* (previously unrecorded for the area) and a form of genet of unknown taxonomic significance were photographed. Bushy-tailed Mongoose *Bdeogale crassicauda* and Selous's Mongoose *Paracynictis selousi* (also previously unrecorded) were fairly convincingly reported. Reports of Spotted-necked Otter *Lutra maculicollis* were equivocal. Two highly nocturnal species (Zorilla *Ictonyx striatus* and African Striped Weasel *Poecilogale albinucha*) expected to be present were not reported and might thus, if predictions are accurate, be of local conservation concern. Side-striped Jackal *Canis adustus* displayed unusual behaviour in its highly diurnal activity and expressed obvious competitive release in almost exclusive use of open plains. Camera-trapping is recommended to complement our current interview methods, which nonetheless are an inexpensive and effective way to capture much-needed data on some poorly-known small carnivore species.

Keywords: interviews, Felidae, Herpestidae, Mustelidae, questionnaires, *Rhynchogale melleri*, Viverridae

Une enquête préliminaire sur la présence et la répartition des petits carnivores dans le Complexe d'Aires Protégées du Bas-Zambèze, en Zambie

Résumé

Une enquête par questionnaire basée sur des entretiens avec des guides touristiques et des gardes-chasse a été entreprise dans le Parc National du Bas-Zambèze et la Zone de Gestion du Gibier de Chiawa dans le sud-est de la Zambie. Elle a permis de mettre en évidence la présence crédible de 15 espèces de petits carnivores appartenant à cinq familles taxonomiques (Canidae, Felidae, Herpestidae, Mustelidae et Viverridae). La présence de deux autres espèces est considérée comme probable, et celle de deux autres est regardée comme peu probable, mais possible. La Mangouste de Meller *Rhynchogale melleri* (préalablement non observée dans la region) ainsi qu'une forme de genette de signification taxonomique inconnue ont été photographiés. La présence de la Mangouste à queue touffue *Bdeogale crassicauda* et celle de la Mangouste de Selous *Paracynictis selousi* (deux espèces également non reportées au paravant) ont été enregistrées de manière relativement convaincante. Des observations de la Loutre à cou tacheté *Lutra maculicollis* étaient équivoques. La présence de deux espèces essentiellement nocturnes (le Zorille commun *Ictonyx striatus* et la Belette rayée d'Afrique *Poecilogale albinucha*) est aussi suspectée, mais ces espèces n'ont pas été enregistrées. Si nos prédictions sont correctes, ces deux espèces pourraient nécessiter des mesures de conservation à l'échelle locale. Le Chacal à flancs rayés *Canis adustus* a affiché un comportement inhabituel de par son activité hautement diurne et exprimé une libération concurrentielle évidente au travers de l'utilisation presque exclusive des plaines ouvertes. Alors que le photo-piégeage est recommandé comme un outil de recherche complémentaire à nos méthodes d'entrevue actuelles, ces dernières offrent malgré tout un moyen peu coûteux et efficace pour obtenir des données plus que nécessaires sur certaines espèces de petits carnivores qui ont été sous-étudiées.

Mots clés: entrevues, félins, mangoustes, mustelidés, questionnaires, *Rhynchogale melleri*, viverridés

Introduction

Many large carnivore species are well researched and documented, but there are significant gaps in the state of knowledge among small carnivores. There is a severe paucity of data on them for much of Africa, as for Latin America (Schipper *et al*. 2009). Small-bodied carnivores (taken here, except where otherwise stated, as those weighing <15 kg) are ecologically diverse, and changes in their community structure and population growth rates can impact ecosystem dynamics (Terborgh 1988, Schreiber *et al*. 1989, Crooks & Soulé 1999, González-Maya *et al*. 2009). 'Mesocarnivores' (those weighing <25 kg) far outnumber large carnivores in species richness and are much more diverse in their behaviour and ecology (Roemer *et al*. 2009), but their often nocturnal and secretive habits make them difficult to monitor (Blaum *et al*. 2008). Of those small carnivore species (defined for this statistic as all species of land Carnivora except cats [Felidae], hyaenas [Hyaenidae], dogs [Canidae] and bears [Ursidae]) with sufficient information to assess their extinction risk, 22% are considered globally threatened by *The IUCN Red List of Threatened Species* (Schipper *et al*. 2008). Effective conservation relies on accurate current data regarding status and distribution, thus surveys in areas where few or no data exist are conservation and management priorities for small carnivores. Determining the current local distribution of carnivores can also help identify possible corridors for movement, to ensure long-term viability and assist management decisions (Purchase *et al*. 2007).

In Zambia, until recently few coherent studies had focussed on small carnivore research (see White 2013). After Ansell's (1978) major work on Zambian mammal distributions, few further data were recorded systematically until 2007, when The Zambezi Society reviewed extensively the status, distribution, and levels of human–carnivore conflict for carnivores in the protected areas and surrounds of the Zambezi Basin, based on a mail-out questionnaire survey (Purchase *et al*. 2007). Large areas within the Zambian protected area network had no or only limited current data regarding status and distribution of many carnivore species.

Within the Zambezi basin, the Lower Zambezi National Park (Lower Zambezi NP) and adjacent Chiawa Game Management Area (Chiawa GMA) (here collectively called the Lower Zambezi Protected Area Complex; Lower Zambezi PAC) are two protected areas located in south-eastern Zambia along the Zambezi River, which are part of the Mana Pools–Lower Zambezi Complex extending into Zimbabwe. This complex was identified as the second most important area for Zambian carnivore conservation, and as an urgent priority area for more detailed survey given the paucity of data for many species, combined with the relatively high expected species richness and presence of some rare species (Purchase *et al*. 2007). In addition, Chiawa GMA is at risk of degradation and habitat loss through human presence and activities. Species data can help determine potential risks to small carnivores there.

Monitoring animal populations in changing environments is crucial to wildlife conservation and management, but the insufficiency of resources poses a recurring problem throughout Africa (Blaum *et al*. 2008). Questionnaire-based methods provide an inexpensive way to obtain information in scenarios where considerable resources would be required for more precise population assessment (Gese 2004). Questionnaires are especially useful when little is known about the biology of the species in question, or for collecting data on rare and elusive species that might otherwise require intensive or long-term camera-trapping efforts (Fanshawe *et al*. 1997, Gese 2001, Llaneza & Núñez-Quirós 2009).

In-depth questionnaire surveys and/or personal interviews of people with intimate knowledge of an area, and who spend much time afield (e.g. hunters, game wardens, rangers and guides) have been used to assess distribution, status and abundance of many animal species and in many ecosystems; Gese (2001) reviewed, briefly, such carnivore studies. Interviews have been used to determine the status of mammals (Gandiwa 2012), carnivores (De Luca & Mpunga 2005, Purchase *et al*. 2007, Kent 2011), and species such as Asian Black Bear *Ursus thibetanus* (Sathyakumar & Choudhury 2007) and Cheetah *Acinonyx jubatus* (Gros 2002). Mail-out methods have been used to assess the local status of Western Polecat *Mustela putorius* (Baghli & Verhagen 2003, Birks 2008), Wild Cat *Felis sylvestris sylvestris* (Balharry & Daniels 1998), Long-tailed Weasel *Mustela frenata longicauda* (Proulx & Drescher 1993, Showalter 2000), African Wild Dog *Lycaon pictus* (Fanshawe *et al*. 1997, Breuer 2003), Grey Wolf *Canis lupus* (Llaneza & Núñez-Quirós 2009) and Pine Marten *Martes martes* (Poulton *et al*. 2006).

We carried out a questionnaire-based survey in 2009 to record small carnivore sightings in the Lower Zambezi PAC over the previous five years. The survey's main aims were to determine the species present in the Zambian side of the complex, to compare with the findings of Purchase *et al*. (2007) and previous records, and to gather preliminary information on small carnivores as a baseline for further research in this area.

Methods

Study area

Lower Zambezi NP covers 4,092 km² and has six tourist lodges, while to the west of the park, Chiawa GMA covers 2,344 km², with more than ten lodges and a number of villages. Both protected areas lie adjacent to the Zambezi River (Fig. 1), and all tourism lodges are lined along the north river bank running west to east. North of the valley is a steep escarpment, bordered by a plateau. Most of the park's wildlife is concentrated along the valley floor, the escarpment acting as a natural barrier. Valley floor elevations range from 370 to 500 m. Given the methods used and the time available, this survey concentrated on the valley floor (approximately 900 km²), where guides and rangers usually drive and patrol.

The area covered, a long, narrow riverside strip of about 130 km, was divided from west to east into four sections: West and East Chiawa GMA, and West and East Lower Zambezi NP (Fig. 2). East Chiawa GMA includes several safari lodges but very few villages, whereas West Chiawa GMA holds most of the villages but only two lodges. West Lower Zambezi NP is here taken to include a small stretch containing two lodges close to, but outside, the park gate, because this area showed very little obvious difference from the park proper in habitat or human disturbance. In addition, separate sections were recorded for the northern hills and escarpment, and for sightings within villages: species recorded in the villages of West Chiawa GMA were not thereby automatically also recorded for the West Chiawa GMA recording section.

Vegetation and habitats

The edge of the Zambezi River (i.e. the Lower Zambezi PAC river bank) is overhung with a fringe of thick riverine woodland, dominated in some places by Natal Mahogany *Trichilia emetica*.

Fig. 1. Location of the Lower Zambezi Protected Area Complex (Lower Zambezi PAC), Zambia.

Grassy marshes spread out into the Zambezi. Further inland are terraced alluvial floodplains, the higher ones being almost bare for most of the dry season. These are interspersed with *Combretum* thickets, palm thickets and open munga woodland, dominated towards the east with Winter Thorn *Faidherbia albida*. The escarpment is covered with miombo woodlands (mainly *Brachystegia manga*).

For the most part, the Lower Zambezi PAC straddles two woodland savannah eco-regions, distinguished by the dominant tree types: miombo, mopane, and southern miombo woodlands on higher ground (in the north); and Zambezian and mopane woodlands on the lower southern slopes. At the edge of the river is floodplain habitat.

Data collection

Small carnivore data were collected over a period of five weeks in October–November 2009. We used a structured questionnaire (Appendix 1) to interview safari guides, camp managers and other staff in all tourist lodges and camps in the park and most of those in Chiawa GMA, following similar methods used by De Luca & Mpunga (2005). Guides all had at least two years of working experience in the area.

Interviewees were shown a pre-prepared booklet including unnamed photographs of 21 small carnivore species possibly present in the area and a few more less likely to be present (see below). They were asked to identify each species, then were asked about the species's presence, and the location, time

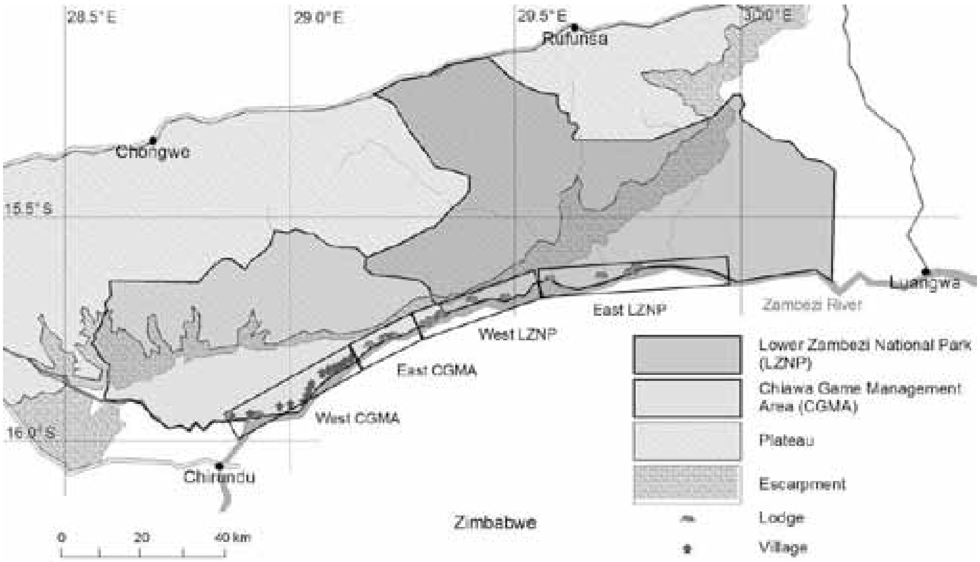

Fig. 2. The Lower Zambezi Protected Area Complex, Zambia, showing geographical sections used in the analysis.

Table 1. Distribution and occupation of interviewees across the Lower Zambezi Protected Area Complex (Lower Zambezi PAC), Zambia.

	Guide	Spotter/ Trainee Guide	Boat driver	Driver	Camp Manager	Camp Owner	Patrol Officer	Total
Kiambi Safari Lodge			3					**3**
Kanyemba Lodge	4							**4**
Mvuu Lodge			4		1			**5**
Baines River Camp	1							**1**
Kasaka River Lodge	2							**2**
Royal Zambezi Lodge	3	1			1			**5**
Community Camp	1							**1**
Conservation Lower Zambezi				1			3	**4**
Chongwe River Camp	6							**6**
Chongwe River House	1							**1**
Chiawa Camp	3					1		**4**
Sausage Tree Camp	4				1			**5**
Mwambashi River Lodge	4				1			**5**
Old Mondoro	2				1			**3**
Kulefu Camp	6	1						**7**
Ana Tree Lodge		1						**1**
Total	**37**	**3**	**7**	**1**	**5**	**1**	**3**	**57**

Sites are arranged west to east.

of day and frequency of sightings. They were also asked open-ended questions about human–carnivore conflict and hunting/poaching, the frequency of problem animal occurrences, and the methods they or others (e.g. village members) used to deal with these species. If an interviewee did not know the identity of a species from the photograph but knew it by name, their data for that species were collected but not included in the analysis. Hereafter 'interviewees' are all people interviewed, while 'respondents' are only the interviewees who reported seeing the relevant species.

In total, 57 people from 16 lodges and camps, and three anti-poaching patrol officers, were interviewed (Table 1). Most interviewees work only along the valley floor, so their data were restricted to this area; but the three officers patrolled the escarpment, so could comment on small carnivores there. Lodges are listed from West to East along the banks of the Lower Zambezi. All camps to the east of the Conservation Lower Zambezi (CLZ) headquarters are considered to be inside the national park (although Chongwe House and Chongwe River Lodge are on the outside edge of the boundary; Fig. 2). Staff at the CLZ headquarters were predominantly Zambian Wildlife Authority or CLZ patrol officers who regularly patrol the foothills as well as the escarpment across East Chiawa GMA to West Lower Zambezi NP and who provided some data on species presence in these difficult-to-reach areas. Additional data were obtained through the authors' direct observation during day and night drives between the lodges during the few weeks of field work.

Each lodge or camp within the park runs daily and nightly tour drives east and west of their camp, overlapping with the neighbouring camps' tours, allowing a continuous coverage of Lower Zambezi NP until the furthermost camp in the East Lower Zambezi NP. Camps in the East Chiawa GMA run game drives into the West Lower Zambezi NP section as well. Thus, observation effort is higher in the latter sector than in the other sectors, and so species are less likely to have been overlooked there. After the last camp, heading eastwards in the park, the road running parallel to the river ends after a few kilometers. The eastern-most area of the park is accessible only by boat. No guides frequent this area, so carnivore sightings were too few for the area to be included in the analysis. Village residents (in West Chiawa GMA) were not directly interviewed: pilot interviews with a local women's group showed that their ability to differentiate between species was limited. Local guides endorsed this view, but several gave accounts of their own sightings in these villages. These guides live in the camps and go home to their village for their monthly leave days.

Species of interest

Background knowledge on small carnivore species in the area was based on respected mammal guides (Ansell 1978, Kingdon 1988, Skinner & Smithers 1990, Skinner & Chimimba 2005), distribution maps in *The IUCN Red List of Threatened Species* (IUCN 2012), and the recent review of the status and distribution of carnivores in the Zambesi basin by Purchase *et al*. (2007). Most small carnivore species in Zambia are listed as Least Concern on the *IUCN Red List* (see Schipper *et al*. 2008); but most listings are based on limited information about status and distribution and some may need revision (Purchase *et al*. 2007).

Several small carnivores have been highlighted as priority species for the Lower Zambezi PAC because they are at the edge of their range, little is known about their status or they are considered at risk. Mills *et al*. (2001) quantified conservation priorities for African carnivores. Three of the small carnivore species expected to inhabit the Lower Zambezi PAC were ranked within that region's twenty carnivores of most conservation concern: Serval *Leptailurus serval*, Bushy-tailed Mongoose *Bdeogale crassicauda* and Cape (or African) Clawless Otter *Aonyx capensis*. Purchase *et al*. (2007) also identified Meller's Mongoose *Rhynchogale melleri* and Spotted-necked Otter *Lutra maculicollis* as of high conservation concern. With their status in Lower Zambezi NP unknown, they are also considered to be species of interest. In total, 21 small carnivore species were investigated. Data about large carnivores (Leopard *Panthera pardus*, Lion *Panthera leo* and Spotted Hyaena *Crocuta crocuta*) are not presented here.

Analyses

Qualitative assessments were carried out for each species according to habitat, activity patterns, perceived frequency and rarity, latest sightings, and interactions or conflict with humans. Habitat types, decided by the interviewees, were categorised into four main groups: open/grassland, forest, riverine and thicket. Activity times were categorised in the questionnaire as active during day, night, dusk, dawn or some combination. Frequency of each respondent's sighting of each species was assessed by combining their frequency of drives (per day or per any other stated time period) with how often they reported seeing each species per drive or per time period: an average per drive was then calculated accordingly. This is an approximation, given that all information came from recall. Interviewees were also asked whether they thought a species was common, occasional or rare. Possible monotonic correlation between the percentage of respondents who perceived a species as rare (i.e. 'perceived' rarity) and the average number of sightings per drive (i.e. 'actual' rarity) was tested with Spearman rank correlation. Statistical analyses were performed with IBM SPSS Statistics 20.

Results

Species sightings

In total, 19 of the 21 small carnivore species in the questionnaire were reported in the Lower Zambezi PAC. Reflecting uncertainty over otter and genet identification to species, records of the two potential species of each were grouped and treated as unidentified otter(s) and unidentified genet(s) respectively. The two species in the questionnaire not recorded by any interviewee were Zorilla (or Striped Polecat) *Ictonyx striatus* and African Striped Weasel *Poecilogale albinucha*. Hence, 17 'species' are considered hereafter. All 17 were sighted in Lower Zambezi NP, 16 in Chiawa GMA, and 11 in or near villages.

Table 2 shows the percentages of interviewees who reported each species, based on the number who visit each section. For example, 100% of interviewees who visit the East Lower Zambezi NP section (n = 27) reported seeing Side-striped Jackal *Canis adustus* there, and of the 25 interviewees who frequent the villages, 44% (i.e. 11 respondents) reported seeing African Civet *Civettictis civetta* there. These figures do

Table 2. Number of respondents recording each species in each section of the Lower Zambezi PAC, Zambia, represented as a percentage of the *n* interviewees using that section, ranked by number of respondents (i.e. interviewees reporting the species)[1].

Species name	**Scientific name**	**Percentage of respondents[2] among interviewees visiting the section[3]**							**Total number of respondents in the PAC**
		West GMA (*n* = 17)	East GMA (*n* = 22)	West Park (*n* = 46)	East Park (*n* = 27)	Hills (*n* = 3)	Plateau (*n* = 3)	Villages (*n* = 25)	
Banded Mongoose	*Mungos mungo*	35	59	89	78	67	33	20	55
Genet[4]	*Genetta*	53	73	83	93	33	0	28	55
Side-striped Jackal	*Canis adustus*	6	9	93	100	0	0	0	52
African Civet	*Civetticus civetta*	94	77	83	85	67	33	44	51
Wild Cat	*Felis silvestris*	71	9	59	81	0	0	36	49
Honey Badger	*Mellivora capensis*	24	45	74	70	33	33	24	49
Common Slender Mongoose	*Galerella sanguinea*	29	55	76	74	33	33	36	48
Serval	*Leptailurus serval*	59	32	46	74	0	0	16	46
Common Dwarf Mongoose	*Helogale parvula*	24	23	83	70	33	33	20	46
White-tailed Mongoose	*Ichneumia albicauda*	6	23	70	89	0	0	0	46
Otter[4]	*Aonyx capensis* and/or *Lutra maculicollis*	59	32	33	11	0	0	20	29
Water Mongoose	*Atilax paludinosus*	6	0	30	15	0	0	4	19
Large Grey Mongoose	*Herpestes ichneumon*	6	0	20	33	0	0	4	18
Caracal	*Caracal caracal*	6	5	20	15	0	0	0	14
Bushy-tailed Mongoose	*Bdeogale crassicauda*	0	0	22	15	0	0	0	12
Selous's Mongoose	*Paracynictis selousi*	0	0	15	4	0	0	0	8
Meller's Mongoose	*Rhynchogale melleri*	0	0	9	0	0	0	0	4
Total number of species in section		**14**	**12**	**17**	**16**	**6**	**5**	**11**	

[1] Note that these figures do not reflect the frequency of sightings per respondent.
[2] Cell shading indicates the percentage of respondents among interviewees:

1–25	26–50	51–75	76+

[3] GMA = Chiawa Game Management Area; Park = Lower Zambezi National Park.
[4] Genet and otter records were pooled, respectively, because species identifications were uncertain; the genets definitely included Rusty-spotted Genet *Genetta maculata* and the otters probably included Cape Clawless Otter *Aonyx capensis*.

not incorporate information on the frequency of sightings per respondent, and any single respondent could report each species from multiple sections. Also, respondents may have reported seeing a species in a village but not within the rest of the West Chiawa GMA section (where the villages are), and the village data are therefore considered separately from the rest of the sections. Conclusions for the hills and plateau should be regarded as preliminary due to low sample size. Some species were reported as seen 'everywhere' by some respondents, but these records were removed from this section of the analysis to avoid assumptions regarding distribution.

Habitat
Most species were found to have a wide habitat range, although a few showed a strong bias towards one or two habitat types (Fig. 3). As with the distribution data, a single respondent could report seeing a species in more than one habitat type. Several respondents reported seeing particular species in 'all habitats'. To avoid possibly unjustified assumptions, those records were removed from this analysis.

Activity
Fig. 4 shows the reported activity times for each species. The score reflects the number of respondents indicating activity at each time, not sighting frequency per respondent. Banded Mongoose *Mungos mungo* and Common Dwarf Mongoose *Helogale parvula* were the most diurnal species (>90% of respondents reporting daytime activity), while Bushy-tailed Mongoose and Meller's Mongoose were the most nocturnal, with 100% of respondents reporting only night-time activity. Side-striped Jackal is, surprisingly, reported to be relatively diurnal (60% of records).

Frequency and rarity
Fig. 5 depicts the perceived rarity and absolute frequency of species observations as assessed by recall. Genets were by far the most frequently sighted survey taxon, with a mean of 3.42 sightings per drive. Wild Cat *Felis sylvestris* ('African Wild Cat' *F. s. lybica*), Side-striped Jackal and Honey Badger *Mellivora capensis* were apparently sighted more often than perceived, i.e. their ranking in average sightings did not match their ranking of perceived rarity. While perceived rarity did not perfectly match actual frequency of sightings, overall there was still a highly correlated inverse relationship between these two variables ($r_S = -0.901$, $P < 0.001$). Frequency differences between Lower Zambezi NP and Chiawa GMA were not quantified, but for most species frequencies seemed higher inside the park.

Latest sightings
All 17 species reported had been seen at least once within the last year by at least one respondent. Nine had been seen in this period by over 50% of the interviewees. Meller's Mongoose

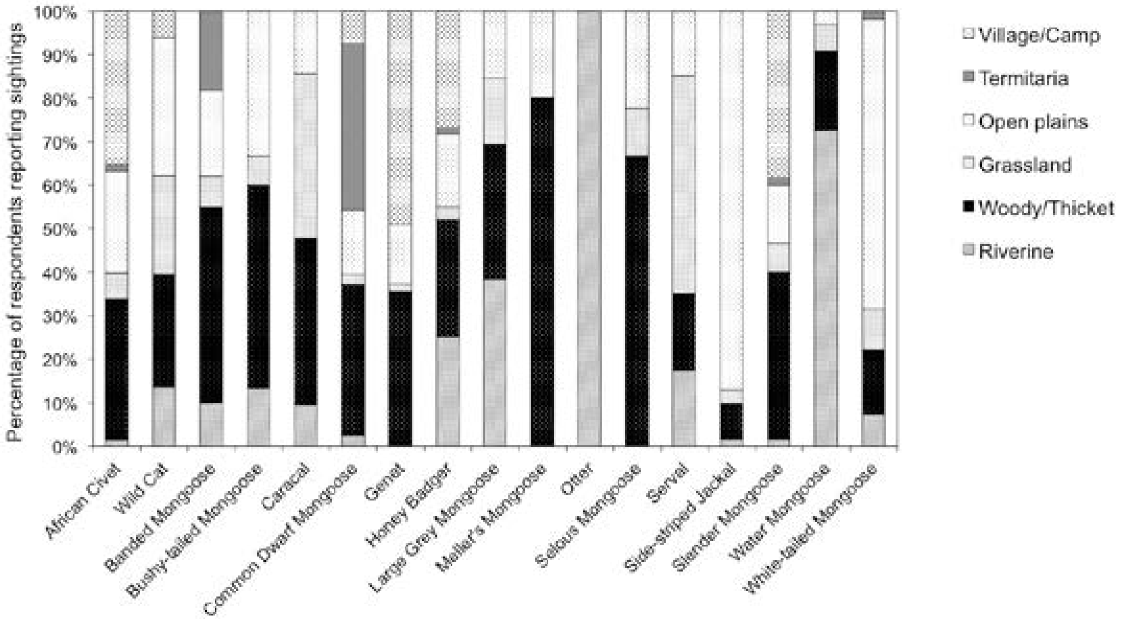

Fig. 3. Habitat-use reports for small carnivores in the Lower Zambezi PAC, Zambia. Scientific names and the number of respondents for each species are given in Table 2.

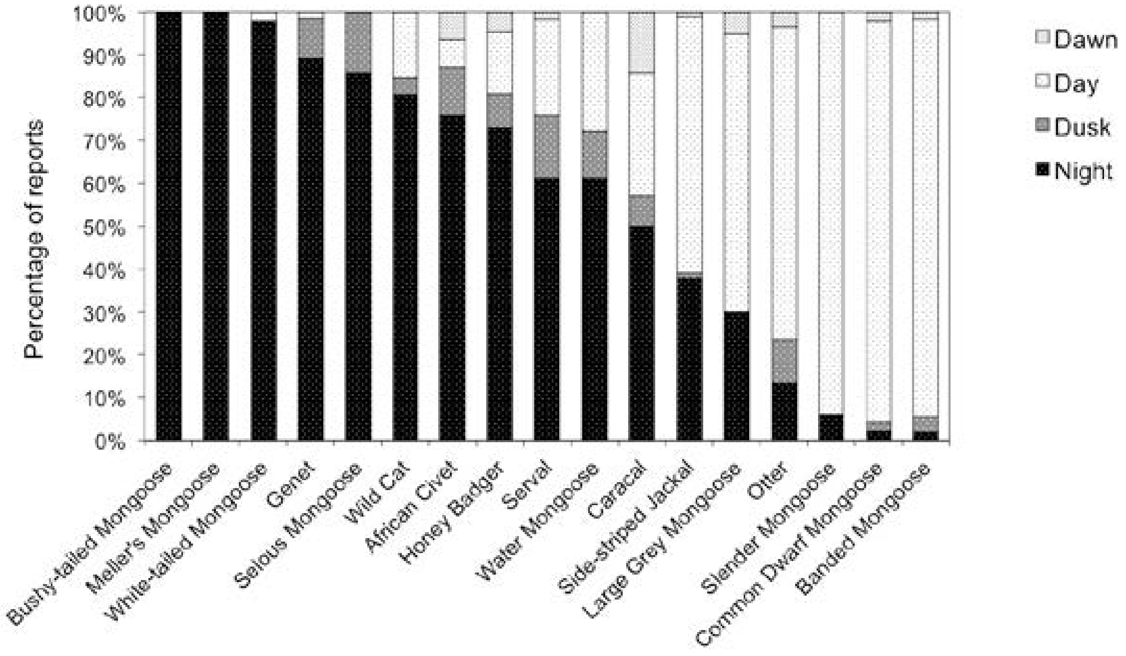

Fig. 4. Reported activity patterns for small carnivores in the Lower Zambezi PAC, Zambia. Scientific names and the number of respondents for each species are given in Table 2.

and Caracal *Caracal caracal* had only been seen by 2% of the interviewees in the last year, suggesting that these species might be rare; although these low rates might also reflect misidentification of rarer species for more common ones, limited overlap between species occurrence and interviewee activity, or various other factors.

Conflict with humans

Human–wildlife conflict was reported for ten species of small carnivores (Table 3), ranging from depredation of livestock to killing of wildlife. The most commonly reported type of conflict was chicken depredation within villages in Chiawa GMA, followed by small carnivores taking food from camp kitchens. Otters were reported to be problematic for fishermen by taking fish out of nets; this may have lead to otter entanglements and mortalities. The most common response by villagers was to kill the animal on site.

Species of previously unsuspected or uncertain occurrence in the Lower Zambezi PAC

Substantial evidence was found for two species first reported for the Lower Zambezi PAC in the 2007 interview survey (Pur-

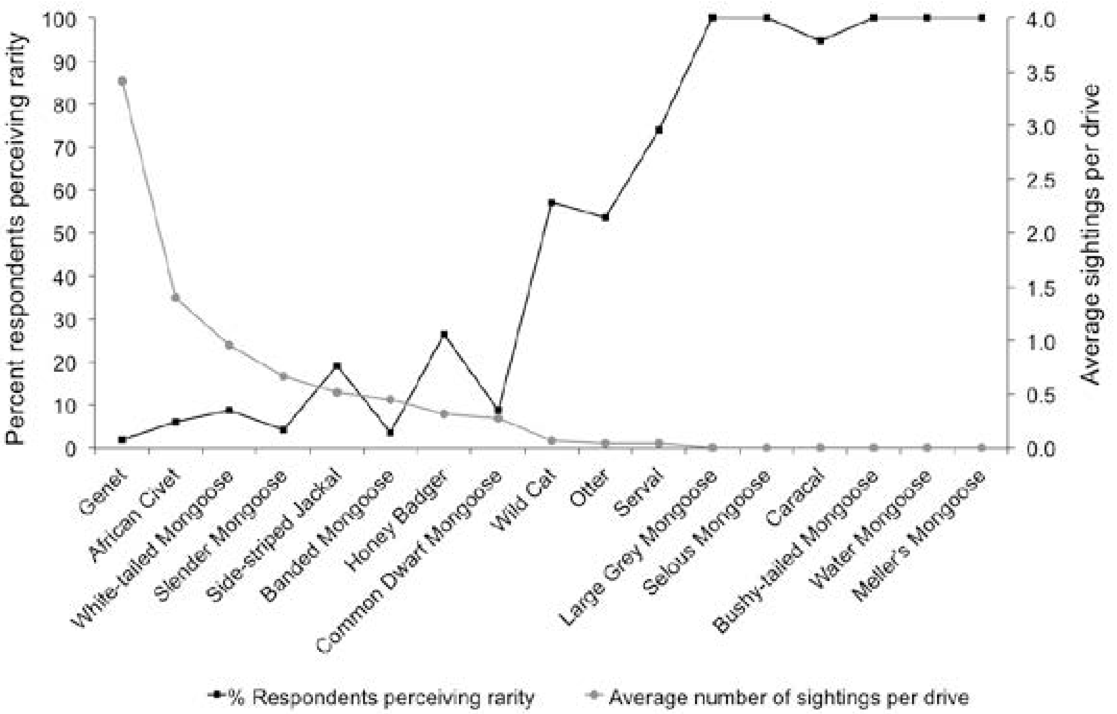

Fig. 5. Comparison of frequency of sightings with perceived rarity of species for each species in the Lower Zambezi PAC, Zambia. Scientific names and the number of respondents for each species are given in Table 2.

Table 3. Summary of human–small carnivore conflicts and currently used responses, as reported by respondents in the Lower Zambezi PAC, Zambia.

Species	ISSUES	Snared	Possible poaching	Eaten by villagers	Conflict with domestic dogs & cats	Conflict with fishermen	Kill chickens	Kill livestock	Take food from camp kitchens/bins	SOLUTIONS	Nothing/ little done	Chased away by villagers	Killed by villagers	Deterred/ killed by village dogs	Protect camp kitchens/ bins	Build strong chicken houses	Keep camp food packed away	Villagers kill hybrid kittens	Removal of snares/ patrols by CLZ/ ZAWA	Number of different types of conflict reported for species
Wild Cat		1			7		22				3	3	10	3		1		2		9
Serval		3	2				8	2			1	1	3						1	8
African Civet				2			7		2			2	1	2	1		3			8
Genet		1					6						2							3
Water Mongoose						1														1
Slender Mongoose							8				4		2	1						4
Banded Mongoose							1						1							2
Side-striped Jackal		1	1		1		1	1												5
Otter				1		7					1		1							4
Honey Badger							11		12		2	3	2	1	10	1	1			9
Total number of species in each conflict type		**6**	**3**	**3**	**8**	**8**	**64**	**3**	**14**		**11**	**9**	**22**	**7**	**11**	**2**	**4**	**2**	**1**	**17**

Scientific names are given in Table 2.
CLZ = Conservation Lower Zambezi; ZAWA = Zambian Wildlife Authority

chase *et al*. 2007): Large Grey Mongoose *Herpestes ichneumon* and Water Mongoose *Atilax paludinosus*. Cape Clawless Otter, reported for the area by both Ansell (1978) and Purchase *et al*. (2007) but considered absent by Skinner & Chimimba (2005), was widely reported. Although it was difficult to be sure that any given otter report was reliable to species, the overall balance strongly indicated the presence of Clawless Otter. Five further species, for which Ansell (1978) traced no records in the area, and for which we traced no specific post-Ansell records, were reported, although the validity of some is open to question. Of the five, we confirmed Meller's Mongoose by photograph, consider Bushy-tailed Mongoose and Selous's Mongoose *Paracynictis selousi* likely to occur, recorded the possible presence of Spotted-necked Otter, and documented a second genet type of unclarified taxonomic significance. Table 4 summarises the historical and current evidence for all eight species, which are discussed in more detail below.

Discussion

The carnivore community of the Lower Zambezi PAC faces an unusual challenge through its confinement by the escarpment to the north, the river to the south and human pressure to the west. Further to the east is another game management area, although not as densely populated as Chiawa GMA. Nevertheless, species richness in the Lower Zambezi PAC appears to be quite high, and most species are still sighted in Chiawa GMA albeit by relatively fewer people than in the park.

Banded Mongoose, African Civet and genet were seen by the highest number of respondents and reported in the greatest number of sections across the Lower Zambezi PAC (i.e. from all sections of Chiawa GMA and Lower Zambezi NP). Differences between Chiawa GMA and Lower Zambezi NP in sighting rates reported by respondents suggest population densities may vary between the sections. Most of the rarely seen species were reported only from the park. This could reflect higher visitation densities in the park, but some level of disturbance avoidance (from the villages in West Chiawa GMA) is likely to be occurring for several species.

Species of particular distributional or ecological interest

Rarely-recorded mongooses

The numbers of interviewees seeing Bushy-tailed, Meller's and Selous's Mongooses remain somewhat unclear: there was some confusion over them, in particular between Bushy-tailed and Meller's. Originally no-one reported seeing Meller's, while 16 respondents reported seeing Bushy-tailed, in thickets mainly in the West Lower Zambezi NP. We opportunistically photographed a Meller's Mongoose in the West Lower Zambezi NP after most of the interviews were finished (Fig. 6), and sent the image by email to the respondents for follow-up consultation. After seeing our photograph, all four respondents who replied changed their identification of their sightings from Bushy-tailed to Meller's. We did not have a good diagnostic photograph of Meller's Mongoose during the interviews, and most guides had not heard about Meller's Mongoose occurring in the Lower Zambezi PAC; and at least one reported that Selous's Mongoose "was not meant to occur in the area", based on field-guide literature. Therefore, if seeing Meller's or Selous's, respondents

Fig. 6. Meller's Mongoose *Rhynchogale melleri* in Lower Zambezi National Park (31 October 2009, 19h33; 15°41′3.22″S, 29°23′56.08″E; recorded altitude: 363 m a.s.l.).

Table 4. Historical and current evidence for small carnivore species not consistently listed as present in the Lower Zambezi PAC, Zambia.

Species	Ansell 1978 (definite records)	Purchase *et al.* 2007 (reported observations)	Skinner & Chimimba 2005 (range map)	IUCN 2012 (2008 *Red List* range map)	This study	Conclusion
Bushy-tailed Mongoose	None	None	In range	In range	12 reports, but see text	Likely
Cape Clawless Otter	Yes	Yes	Out of range	In range	21 reports, including 1 of prints	Highly likely
Large Grey Mongoose	None	Yes	In range	In range	18 reports	Highly likely
Meller's Mongoose	None	None	In range	In range	4 reports, but see text; photographed	Confirmed
Selous's Mongoose	None	None	In range	In range	8 reports	Likely
Spotted-necked Otter	None	None	Out of range	Out of range	2 reports	Unlikely
Water Mongoose	None	Yes	Out of range	In range	19 reports	Highly likely
Second genet species	None	None	None	None	6 reports of '2nd type'; photographed	Possible (P. Gaubert verbally 2012)

Scientific names are given in Table 2

may have assumed they were seeing another species. Nevertheless, two guides, who did not reply to the email with the photograph, were "very sure" that they had seen Bushy-tailed, on more than one occasion. Eight respondents reported seeing Selous's Mongoose, three of whom also reported having seen a different rare mongoose (either Bushy-tailed or Meller's). Two respondents claimed to be very sure of the identity as Selous's Mongoose, and three gave detailed descriptions of the species. All but one of the 21 respondents who reported seeing any of these three apparently rare species had been guiding or working in the park for at least four years, some as many as 20 years. Thus, they seem likely to differentiate correctly how many species they see, even if they misname them. Meller's and Bushy tailed Mongooses were camera-trapped frequently in Zambia's Luangwa Valley (White 2013), suggesting that their presence in the Lower Zambezi PAC may be much underestimated by interviewees. Meller's and Bushy-tailed Mongooses were also recently recorded in Tanzania's Udzungwa Mountains (De Luca & Mpunga 2005), with surprisingly high capture rates for Bushy-tailed, suggesting that these species may be more widely distributed than originally thought. Bushy-tailed is associated with mopane woodland and rocky outcrops (Skinner & Smithers 1990), possibly making the Lower Zambezi PAC's combination of valley floor and escarpment a highly suitable area for this species. In sum, all three species plausibly occur within this area, but further research (such as camera-trapping) is needed to clarify their status there.

Cape Clawless Otter

Cape Clawless Otter was reported by 21 respondents, supporting the view of Purchase *et al*. (2007) that it occurs between Victoria Falls and the Mozambique Zambezi delta. Eight other respondents reported otters but were unsure of species identification. There were several reports of conflict with fishermen; otters eat fish in the nets, causing loss to fishermen, and can become entangled and drown in the nets. One local guide reported that villagers have been known to eat them. De Luca & Mpunga (2005) reported high levels of illegal hunting of otters in the Udzungwa Mountains, more often for traditional medicine and ceremonial purposes. Given the relatively high-quality habitat available for them in Lower Zambezi PAC and the high likelihood of fishing impacts and consumptive mortality (Skinner & Chimimba 2005), measures are warranted to reduce impacts of local fishing and traditional practices on this population.

Spotted-necked Otter

Two respondents reported seeing Spotted-necked Otter. They could have been misidentifying Cape Clawless Otter or Water Mongoose, although both said that they had also seen Clawless Otter and one claimed also to have seen Water Mongoose. One boatman not interviewed formally, working in the Rufunsa Game Management Area east of Lower Zambezi NP for more than 17 years, said he had heard two different types of call from otters he sees in Rufunsa GMA, leading him to believe both species are present; but this could be misidentification of Water Mongoose or variation of calls within Clawless Otter.

Water Mongoose

Water Mongoose was reported for both Chiawa GMA and Lower Zambezi NP by Purchase *et al*. (2007) but not recorded previously (Ansell 1978, Skinner & Chimimba 2005). Nineteen respondents reported seeing Water Mongoose, of whom only two were doubtful of its identity. Of these 19, 12 also reported seeing at least one otter species, suggesting that most could distinguish between the two. In Congo's Dzanga-Sangha Reserve, Water Mongoose and Congo Clawless Otter *Aonyx congicus* do not frequent the same small streams within the forest (Ray 1997), and in the Udzungwa Mountains Water Mongoose was not captured in the same vicinity as Cape Clawless Otter (De Luca & Mpunga 2005). Water Mongoose was not reported from Chiawa GMA, while Clawless Otter was reported across the Lower Zambezi PAC. Within the Lower Zambezi NP, both species were reported in the same areas, but the sampling units used might be too coarse to measure any real separation.

Large Grey Mongoose

Large Grey Mongoose, while expected to be in the Lower Zambezi PAC (Skinner & Chimimba 2005, Cavallini & Palomares 2008), had not been reported there until recently. Ansell (1978) noted the lack of records, but suggested that it probably occurred there. Purchase *et al.* (2007) reported it from both Lower Zambezi NP and Chiawa GMA. Eighteen respondents reported seeing it in this study, making its presence in the LZPAC highly likely, especially as no confusion with other species was apparent. All respondents reported the species as rare, seeing it on average only 0.2 times a year; 68% of interviewees had never seen it. This species is largely diurnal and distinctive in appearance, so its low reporting rate suggests genuine scarcity. Only one report came from outside Lower Zambezi NP. The species's local conservation status might, therefore, be a cause for concern.

Serval and Caracal

De Luca & Mpunga (2005) suggested that high densities of Leopards and Spotted Hyaenas in the Udzungwa Mountains could cause intra-guild competition to the detriment of Serval and Caracal. While Caracals were considered very rare in the Lower Zambezi PAC, Servals were reported to be relatively widespread across it, with a surprisingly high number of respondents in the West Chiawa GMA section. This could stem from higher domestic prey (chickens) availability in the village sections, where conflicts were reported, than in the relatively undisturbed East Chiawa GMA section. Nevertheless, most Serval sightings were reported inside the Lower Zambezi NP. Here, larger predator species also seemed more common than in Chiawa GMA (TLFB & CWM own data), indicating that if such competition occurs, it is not intense enough to prevent Serval being common.

Genets

To test interviewees' knowledge of genets in the area, we included photographs of Rusty-spotted Genet *Genetta maculata*, Small-spotted Genet *G. genetta* and Angolan (or Miombo) Genet *G. angolensis*, although the latter two are unlikely to occur near the Lower Zambezi PAC (Gaubert *et al*. 2005, Purchase *et al*. 2007). Of the interviewees who saw a genet, most identified the species as *G. maculata* (the expected species), but 13% of respondents claimed to be seeing a second form in the park as well, which (based on survey photographs we showed them and their own perusal of field guide books), they considered to be most similar to *G. genetta*.

In response to these speculations we undertook several

Fig. 7. Rusty-spotted Genet *Genetta maculata* (typical appearence) in Lower Zambezi National Park.

Fig. 8. Genet *Genetta* of unresolved identity ('second form') in Lower Zambezi National Park (9 November 2009, 19h47; approximately 15°38′S, 29°34′E; altitude: approximately 350 m a.s.l.).

night drives and took photographs of what appear to be two different forms (Figs 7–8). Several respondents described *G. maculata* (Fig. 7) as larger, more heavily built, and of darker base-colour with larger spots, and the second form (Fig. 8) as smaller, of leaner build, of paler base colour and with smaller, more linear spots. Our photographs of this second type show a black-tipped tail, ruling out both *G. genetta* and *G. angolensis*; but it is unclear whether the animal is an unusual form of *G. maculata* or possibly a pale form of Servaline Genet *G. servalina*, which sometimes occurs in East Africa (Tanzania) (P. Gaubert verbally 2012). The Lower Zambezi PAC lies far south of Servaline Genet's currently known range, from Cameroon to Kenya (Gaubert *et al*. 2005). No positive identification can be made of our few night images: genets in this area warrant further investigation.

Side-striped Jackal

Canis adustus is not considered to be of conservation concern, but its reported behaviour in the Lower Zambezi PAC is of interest; nearly all respondents reported it as highly diurnal or as nocturnal and diurnal, and almost exclusively sighted it in open plains and other open areas. Observations were mainly reported from Lower Zambezi NP and rarely in Chiawa GMA, perhaps depending more on the availability of open plains in these respective areas rather than avoidance of people. It is typically considered highly nocturnal or occasionally crepuscular (Kingdon 1988, Stuart & Stuart 2001, Loveridge & Macdonald 2002, 2003, Skinner & Chimimba 2005, Brown & Peinke 2007). It is scarce in open areas where it is sympatric with Black-backed Jackal *C. mesomelas* and/or Golden Jackal *C. aureus*, reflecting competition and aggressive exclusion by the smaller *C. mesomelas* (Fuller *et al*. 1989, Loveridge & Macdonald 2003, Skinner & Chimimba 2005). These latter two jackal species seem not to inhabit the Lower Zambezi PAC, and regular use by *C. adustus* of open areas there echoes Loveridge & Macdonald's (2003) demonstration of its competitive release.

Other species

In spite of expectations that they occur in the area, neither Zorilla nor African Striped Weasel were recorded by any interviewee, even though some had worked there for 20 years. This zero result could reflect these species' entirely nocturnal nature (Larivière 2002, Skinner & Chimimba 2005) rather than their absence from the area. The latest night drives finished by 20h00, so species active only after this time were unlikely to be observed. Skinner & Chimimba (2005) also stated that owing to African Striped Weasel's small size, short legs and low-slung body, observations in the field were meagre. Both species are widespread in Africa, and the Lower Zambezi PAC is within their expected ranges and habitats (Skinner & Smithers 1990). Further investigation should use other survey methods, such as camera-trapping, to assess their status in this area.

Using questionnaires to capture data

Certain assumptions and biases, reflecting the interview methods used, may have affected results and conclusions. Nocturnal and/or cover-haunting species are less easily spotted than diurnal and/or open habitat ones. To maximise animal sightings for tourists, most guides were more active during daylight and in open areas near roads, a pattern exacerbated by the need for Chiawa GMA guides to leave the park by 20h00, when the gates close. Skulking, nocturnal and forest species are much less likely to be observed so warrant survey by methods such as camera-trapping.

A major concern when investigating species status by questionnaires is the reliability of identification. As well as the challenges of sometimes poor visibility and fleeting glances, many guides use books that include range and behaviour information. This is sometimes incomplete and even inaccurate, misleading interviewees into false species identifications of their sightings. For example, Meller's Mongoose is poorly described in most field guides, often without a photograph. In this survey a few species unlikely on known range to inhabit the Lower Zambezi PAC were added to test interviewees' knowledge of species in the area, as well as to allow for the possibility of unexpected occurrence: Small-spotted and Angolan Genets, and Aardwolf *Proteles cristatus*. The first was reported by seven (13%) interviewees, but neither of the other two were reported by anyone. Given the presence of genets of genuinely confusing appearance (see below), these results suggest generally good recognition skills among interviewees.

White (2013) surveyed nocturnal species using camera-traps, but this method alone would not necessarily have been more effective for our study. It requires intensive sampling effort and is much more expensive, is highly restricted in information it can collect on topics like human–wildlife conflicts and on pre-survey population trends, and its results are highly dependent on camera placement. Interviews of guides and patrol officers, who collectively spend hundreds of hours a week in the field sighting animals, generated much information not obtainable from camera-traps. Camera-trapping detected 15 carnivore species in Tanzania's Udzungwa mountains out of the 26 assessed as present through interviews, live traps and direct observations (De Luca & Mpunga 2005). Similarly, TAWIRI (2010) camera-trapped only 35 of mammal species in an area where "after eliminating species that were obviously incorrectly identified" (p. 9) there were a further 26 species reported by villagers that were not camera trapped – although several more of these were also felt to be dubious, and several others were not particularly well suited to camera-trapping but were seen directly by the survey team. Thus, camera-trapping provides verifiable evidence and data more easily quantified, but interviewing local wildlife professionals is an efficient source of species status information that is more likely to identify human impacts on these species.

Anthropogenic impacts on small carnivore distributions

Our initial interest was to compare Lower Zambezi NP with Chiawa GMA for relative abundance and distribution, but because most guides, even in Chiawa GMA, went straight into the park for game drives, this comparison was challenging and the results should be interpreted with care. Nevertheless, populations of most species seem larger within the park than in Chiawa GMA. This statement is based on various assumptions and may not reflect the true pattern within the Lower Zambezi PAC. Nonetheless, this fits a well documented pattern of some carnivores avoiding human-populated areas. This could reflect habitat change to offer less shelter, or less (and/or less diverse) food (De Luca & Mpunga 2005, Martinoli *et al*. 2006), or direct persecution, and/or mortality from domestic dogs and cats.

Human–carnivore conflict is often associated with large carnivores given the danger they pose to human life and livestock (Treves & Karanth 2003). However, several species of small carnivores were considered to be problem animals in the Lower Zambezi PAC, including Wild Cat, which reportedly often killed chickens in villages, and Honey Badger, which raided camp kitchens and rubbish bins. In addition, otters may die from conflicts with fishermen, either as a direct target or indirectly through entanglement in nets.

Conclusion

This study was a pilot to determine knowledge gaps, species status and future research needs for the Lower Zambezi PAC. Small carnivores' roles in ecological ecosystems remain poorly known despite greater attention recently (Crooks & Soulé 1999, Prugh *et al*. 2009, Roemer *et al*. 2009). An ecological study of the Lower Zambezi PAC's overall carnivore guild would clarify small carnivores' ecological roles there. Camera-trapping would complement interviews, particularly with rare mongooses and with genets. There is a pressing need to clarify the status of Zorilla and African Striped Weasel in the Lower Zambezi PAC, both predicted to inhabit the area but not reported in the present interviews. Whilst they might simply be overlooked, or the predictions might be wrong, the lack of reports might indicate a so-far overlooked conservation issue.

Current trends in human population growth and habitat loss mean that the persistence of many carnivore species is likely to depend on their survival outside protected areas, where they may come into conflict with humans (Kent 2011). In this study few small carnivore species were reported in significant levels of such conflict. Protection of undisturbed areas and prevention of encroachment of the park will assist long-term conservation of these species in particular.

Scientific knowledge of these species' populations and of the perceptions and attitudes of the people living in the same area is therefore of great importance to their continued existence. Local knowledge can serve as a valuable source of ecological information to complement scientific information for wildlife conservation and management (Gandiwa 2012). Further research focusing on local (village) knowledge, perceived population trends, and attitudes towards small carnivores, will assist informed conservation practices for these species in the Lower Zambezi PAC.

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The authors wish to thank the Zambia Wildlife Authority for permission to conduct research in the study area as well as Conservation Lower Zambezi and Old Mondoro Bush Camp for hosting us and for invaluable logistical assistance. We thank John Kalidza, for his time driving to every camp in the Lower Zambezi PAC, and we also thank the Zambia Wildlife Authority patrol officers, and management and staff of the lodges in the Lower Zambezi PAC who contributed their time and knowledge to this effort as interviewees. We are grateful to Gianetta Purchase for her advice in planning and her previous research in this field, and to all the advisors who provided invaluable information regarding species identification, particularly Phillippe Gaubert, Derek Solomon, Egil Droge, John Coppinger, Robin Pope and Charles Foley. Lastly we are indebted to Emmanuel Do Linh San for his invaluable advice and help with the final manuscript.

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Appendix 1. Questionnaire used in surveys of carnivores in the Lower Zambezi Protected Area Complex.

Interviewees were shown photographs of 28 species of carnivores, most of which were expected to occur in the area. These included 21 species of small carnivores.

Information about Interview and Interviewee

1	Name of interviewee		
2	Location of interview		
3	Occupation of interviewee		
4	Other places worked		
5	Years lived in LZPAC		
6	Area regularly visited		
7	Frequency of drives		
8	Date interviewed		
9	Name of researcher conducting interview		

Species information

10	Species photo ID number (from photo booklet)	1	2	…	28
11	Species Name (given by interviewee)				
12	Have you ever seen this species in the wild in this area?				
13	If yes, when was the last time you saw this species (month and year)?				
14	What time of day do you normally see it (Day/Night/Dusk/Dawn)?				
15	Where do you see the species?				
16	What habitat have you seen it in (open grassland/forest/river/road, etc.)?				
17	How many do you see in together?				
18	What is the largest number you have seen in a group?				
19	Have you seen young/sub-adults/juveniles? How many?				
20	How many times have you seen this species in the last year (or per week or month)?				
	Opinion				
21	How abundant do you think the species currently is in the area (rare/occasional/ common/don't know)?				
22	Over the last 5 years, do you think that this species numbers in the area are increasing/ decreasing/the same?				
23	Do you like this species (yes/no/don't know)?				
24	Would you like this species to increase/ stay the same/ decrease/ don't care? Why?				
	Conflict issues				
25	Do you know of any problems involving this species or any conflict issues? Explain.				
26	How do you or your community deal with the problems - e.g. fencing/chasing away/ killing/reporting to Zambia Wildlife Authority				
27	Any other comments				

Diversity and distribution of small carnivores in a miombo woodland within the Katavi region, Western Tanzania

Claude FISCHER*, Romain TAGAND and Yves HAUSSER

Abstract

The central Zambezi miombo woodlands represent an extended, unfenced ecosystem in Western Tanzania. Few biodiversity surveys have been conducted in this ecosystem, except in its National Parks. In 2007, we surveyed medium- and large-sized mammals in Mlele District, north of Katavi National Park, in an area managed by local communities. This survey was extended in summer 2012 to the neighbouring Rukwa Game Reserve. Transect surveys, camera-traps and opportunistic encounters detected 10 species of small carnivore out of the 14 potentially present in the combined area. Thus, the small carnivore guild was diverse, despite the area's low protection status. Bushy-tailed Mongoose *Bdeogale crassicauda* appeared much more common than expected, and at least two species of genet and six of mongoose occur.

Keywords: camera-trap survey, forest reserve, game reserve, transect survey

Diversité et distribution des petits carnivores dans une zone boisée de miombo au sein de la région de Katavi, en Tanzanie occidentale

Résumé

Les forêts de miombo représentent un vaste écosystème naturel et non-clôturé dans l'Ouest de la Tanzanie. Le nombre d'inventaires faunistiques réalisés dans cette région est réduit, à l'exception des Parcs Nationaux. En 2007, nous avons mis sur pied un inventaire des mammifères de taille moyenne et grande dans le district de Mlele, au nord du Parc National de Katavi, dans une zone gérée par les communautés locales. En 2012, cet inventaire a été élargi à la Réserve de Chasse de Rukwa. Une combinaison d'inventaires sur transects, par pièges-photographiques et par rencontres opportunistes nous a permis de détecter la présence de 10 espèces parmi les 14 potentiellement présentes dans cette région. La guilde des petits carnivores était donc diversifiée, et ce malgré un faible niveau de protection dans la zone d'étude. La Mangouste à queue touffue *Bdeogale crassicauda* semblait être plus commune qu'attendu et la présence d'au moins deux espèces de genettes et de six espèces de mangoustes a pu être confirmée.

Mots clés: inventaire par pièges-photographiques, inventaire sur transects, réserve de chasse, réserve forestière

Introduction

Extended areas of miombo woodlands – central Zambezi miombo woodlands (Burgess *et al*. 2004) – are still widespread in western Tanzania. The Katavi region supports over 19,000 km^2 of this ecosystem, under varying protection status, from National Park (Katavi), through Game Reserves, Forest Reserves and community managed areas such as Wildlife Management Areas or Beekeeping Zones, to village lands. There are no separating fences, so animals can roam across the entire ecosystem.

This still extensive natural ecosystem has had few mammal surveys, except in Katavi National Park and its immediate surroundings (Caro 1999a, 2011, Waltert *et al*. 2008). The few data for the rest of the area are from aerial surveys (Stoner *et al*. 2007) and, more locally, daytime transect counts using vehicles (Caro 1999b, 2008). These methods are adapted for larger mammal species, particularly in this kind of habitat, but the presence and distribution of many smaller or elusive species remains un-, or poorly, documented.

In 2007, we initiated a detailed survey of the mammal community of 900 km^2 within a forest reserve and beekeeping zone in the ecosystem's centre (Fig. 1). This survey was conducted in the framework of a community-based natural resource management project initiated in 2001, which focused on local communities' development of beekeeping activities (Hausser *et al*. 2004). The objective was to develop a tool to evaluate the sustainability of such a community-based management approach by assessing the evolution in space and time of the diversity and distribution for one group of organisms, mammals. The survey was extended south of the beekeeping zone in 2012, covering the northern half of neighbouring Rukwa Game Reserve: an additional 1,200 km^2. This second step aimed to compare the results of a management system allowing communities to use natural resources, with one in which local communities have only very limited access. These surveys are intended to occur yearly, to assess temporal trends.

The present paper presents the surveys' data on the presence and distribution of small carnivores in the families considered by *Small Carnivore Conservation*: in Africa, Herpestidae, Mustelidae, Nandiniidae and Viverridae.

Study areas

The first study area, Mlele Beekeeping Zone (Mlele BKZ) lies north of Katavi National Park (Katavi NP) in the newly created Mlele district (Fig. 1). It is dominated by miombo woodlands, interspersed with few seasonally inundated swamps and grasslands totalling less than 5% of the area (Fig. 2). The area's two plateaux are separated by a steep escarpment. The north-east plateau lies at a mean altitude of 1,000 m and rep-

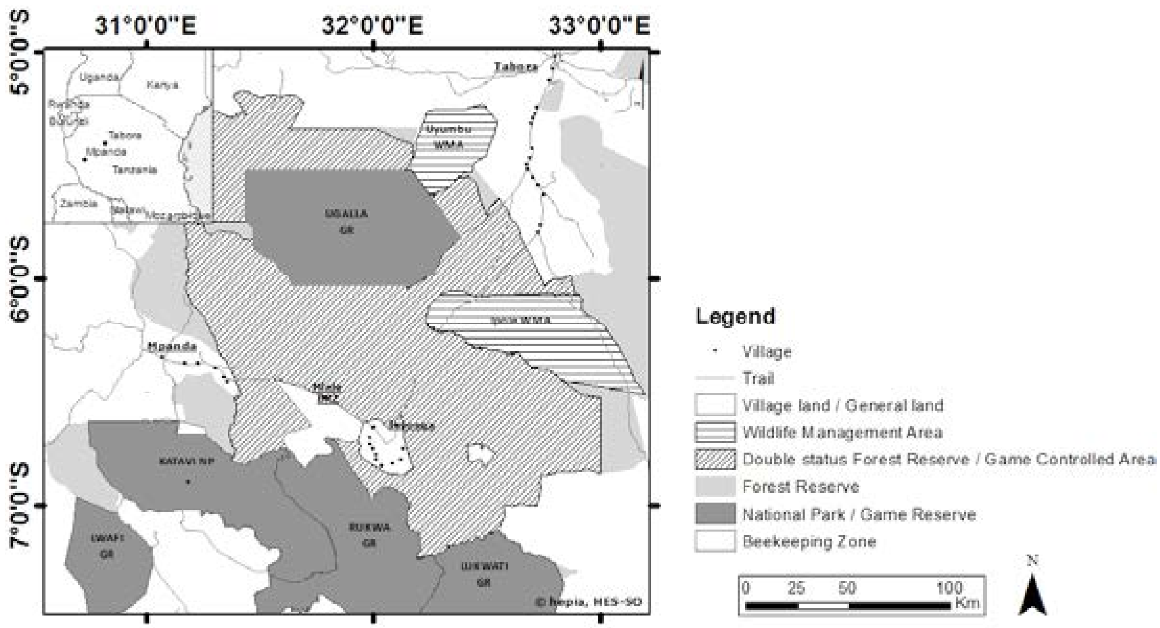


Fig. 1. Location of the study areas, Mlele Beekeeping Zone and the northern part of Rukwa Game Reserve, within the extended miombo woodlands of western Tanzania.

resents two-thirds of the area. The south-west plateau has a mean altitude of around 1,400 m.

The second study area, northern Rukwa Game Reserve (Rukwa GR-n), lies south-east of Mlele BKZ and east of Katavi NP (Fig. 1). Its landscape is much more rugged, with a higher plateau reaching over 1,600 m. A complex system of deep escarpments divides it into several canyons to the south and south-east.

The escarpments crossing both areas represent a side branch of the East African Rift. Both areas' seasonal climate gives a December–April wet season and a May–November dry season. Few water bodies are permanent: most of the area is under very dry conditions for several months.

Methods

The methods, detailed in Hausser *et al*. (in prep.), consisted of three monitoring techniques. During the project's first three years (2007–2009), transect surveys in four-wheel drive cars visited extensive portions of the five accessible road stretches of Mlele BKZ (Fig. 2) early in the morning and by night. This method was abandoned in 2011 because the two other techniques proved to be sufficient and because repeated car breakdowns, linked to rough road conditions, rendered the method costly. Secondly, in 2011–2012 for Mlele BKZ, and in 2012 in Rukwa GR-n, a grid of camera-traps covered half of each study area. The grids consisted of non-contiguous squares of 10 × 10 km, five in Mlele BKZ and four in Rukwa GR-n. These were each divided in smaller squares of 2 × 2 km (Fig. 3). In each of the larger squares, 12 intersections delineated by the smaller squares were selected randomly to set a camera-trap. In the field, we looked for visible signs of mammal activity in a radius of 50 m around the selected intersections to improve the probability to get pictures. Camera-traps were set for periods of 21 days. Some camera-traps set in the previous years to test the system were placed opportunistically along roads and trails. Given the aim to assess status of many species of medium-sized and large mammals, camera-traps were set 60–100 cm above ground. The model used, the Cuddeback Capture, is easy to run, even for local people, relatively cheap, and produces pictures of fairly good quality. Thirdly, all opportunistic encounters with small carnivores, whether by car or on foot, were noted.

These techniques generated first results on the composition and distribution of the area's mammals, excepting fossorial, aerial and small (body mass <1 kg) species. All surveys reported here were conducted during the dry season, so some species using the area might have gone undetected. All species recorded during 2007–2010 are listed in Hausser *et al*. (in prep.).

Results

Surveys began in 2007 in Mlele BKZ, with a mean field presence of one month per year. Total survey effort was 1,589 camera-trap-days and five transects repeated five to six times each. In Rukwa GR-n we spent only two months in 2012, with an effort of 904 camera-trap-days.

Ten species of small carnivores, of the 14 potentially present (after TAWIRI 2009), were identified (Table 1). An eleventh, African Palm Civet *Nandinia binotata*, was seen too poorly for certain identification. Genet *Genetta* identification to species was difficult during direct encounters: they were seen only at night and usually hid quickly. Even one genet camera-trap picture defied identification.

Genets were both camera-trapped and encountered directly (on transects or opportunistically), always by night (Table 1). Two species of mongooses, Marsh Mongoose *Atilax paludinosus* and Bushy-tailed Mongoose *Bdeogale crassicauda*, were detected only by camera-traps and only at night. Common Dwarf Mongoose *Helogale parvula* and Common Slender Mongoose *Herpestes sanguineus* were found only by direct encounters, only by day. White-tailed Mongoose *Ichneumia albicauda* and Banded Mongoose *Mungos mungo* were often seen directly, but were also

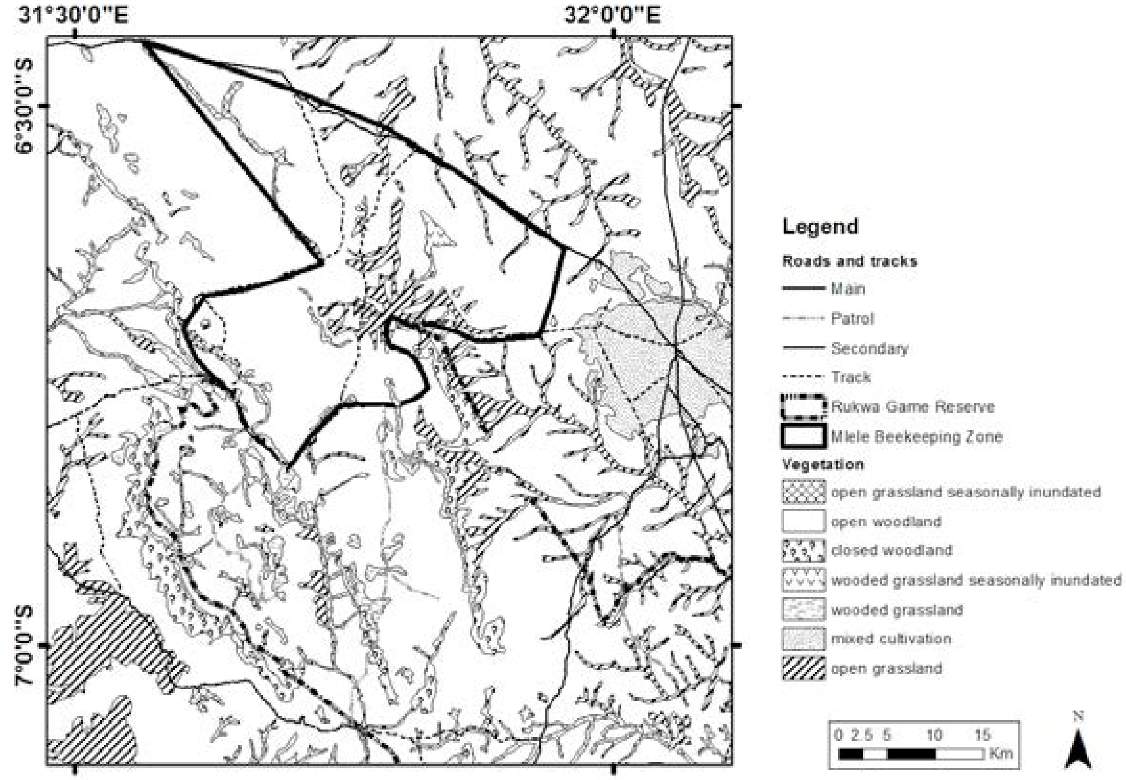


Fig. 2. Vegetation of Mlele Beekeeping Zone and the northern part of Rukwa Game Reserve, Tanzania. Open woodland = miombo.

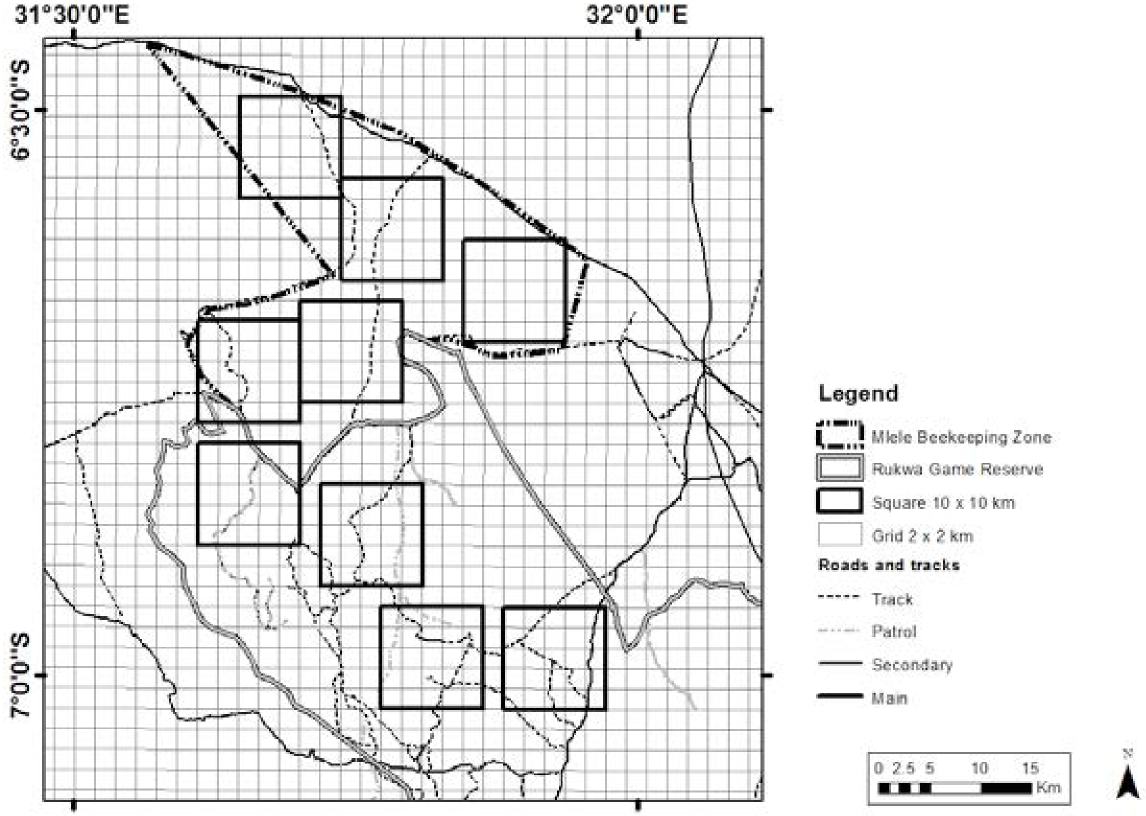


Fig. 3. The camera-trap grid system in Mlele Beekeeping Zone and the northern part of Rukwa Game Reserve, Tanzania.

Table 1. Small carnivore species potentially present in Mlele Beekeeping Zone and the northern part of Rukwa Game Reserve, Tanzania (after TAWIRI 2009), detailing those observed during 2007–2012 surveys.

Species[1]	Scientific name	Species detected	Number of sites[2] Mlele BKZ / Rukwa GR-n	Method[3]	Activity pattern observed
Miombo Genet	*Genetta angolensis*	YES	3/4	C, Tn	Night
Rusty-spotted Genet	*Genetta maculata*	YES	1/-	C	Night
Common Genet	*Genetta genetta*	NO	0	-	-
Common Dwarf Mongoose	*Helogale parvula*	YES	17/-	T, O	Day
Banded Mongoose	*Mungos mungo*	YES	6/-	C	Day & night
Common Slender Mongoose	*Herpestes sanguineus*	YES	1/-	T, O	Day
Egyptian Mongoose	*Herpestes ichneumon*	NO	0	-	-
White-tailed Mongoose	*Ichneumia albicauda*	YES	4/1	C, T, O	Day & night
Marsh Mongoose	*Atilax paludinosus*	YES	7/1	C	Night
Bushy-tailed Mongoose	*Bdeogale crassicauda*	YES	6/2	C	Night
Honey Badger	*Mellivora capensis*	YES	5/5	C, O	Day & night
Zorilla	*Ictonyx striatus*	NO	0	-	-
African Civet	*Civettictis civetta*	YES	3/5	C, O	Night
African Palm Civet	*Nandinia binotata*	Probable	[1]/-	Tn	Night

[1] Otters are not considered as potentially present because there are no permanent water bodies in our study areas.
[2] The number of sites represents the number of camera-trap locations and the number of direct sightings separated by at least 100 m.
[3] C = camera-trap, T = day-time transect, Tn = night-time transect, O = opportunistic encounter.

camera-trapped, by both day and night. Honey Badger *Mellivora capensis* and African Civet *Civettictis civetta* were mostly camera-trapped, but there were some direct encounters: at night for African Civet, and, once, by day for Honey Badger.

Detection locations of each species (Fig. 4) give some broad information about their distribution, but need cautious interpretation: only two months were spent in Rukwa GR-n versus nine in Mlele BKZ. This big difference in sampling effort resulted in more observations in Mlele BKZ, except for African Civet (Table 1).

Discussion

Camera-trap models and survey techniques not specially adapted for small carnivores found a fairly complete small carnivore guild: 10 species from a predicted 14 species present in the area. Other species may be present: a probable African Palm Civet – a species of uncertain distribution in western Tanzania (Stuart & Stuart 2006, Wilson & Mittermeier 2009) – was seen in 2007, and several genets were not identified to species.

Additional species would plausibly be recorded by camera-trapping more focused on small carnivores, which would: mount them lower to the ground (20–40 cm; Sarmento *et al*. 2010, 2011, Ancrenaz *et al*. 2012); place some beside roads, trails, latrines and termite hives; use lures; and use more sensitive detectors. For instance, we never camera-trapped Common Dwarf Mongoose, despite several direct observations. The species may be too small and not mobile enough to be readily detected by our camera-trap system; and 2-km grid-cells exceed its usually small home range (<1 km^2; Gilchrist *et al*. 2009).

Our survey unveiled a surprisingly high carnivore species richness. Pettorelli *et al*. (2010) surveyed carnivores in 11 Tanzanian sites, including eight of protection status higher than (six national parks and Ngorongoro Conservation Area) or similar to (one game reserve) our study areas. They recorded 4–16 species of carnivores per site: only three had 10 or more species. We recorded 17 carnivore species in Mlele BKZ: the ten above plus African Wild Dog *Lycaon pictus*, Side-striped Jackal *Canis adustus*, Lion *Panthera leo*, Leopard *Panthera pardus*, Serval *Felis serval*, African Wild Cat *Felis sylvestris* and Spotted Hyena *Crocuta crocuta*. Yet Mlele BKZ is an area with the lowest protection status (IUCN management category VI).

Bushy-tailed Mongoose, which we recorded in both our study areas, in eight different sites, deserves special mention. It was considered uncommon by Kingdon (1997), De Luca & Mpunga (2005), Wilson & Mittermeier (2009), TAWIRI (2009) and C. Foley (*in litt*. 2012), but Pettorelli *et al*. (2010) pointed out that it can be more widespread: they recorded it in 31 locations across five study areas. Similarly, there were very few previous observations of Miombo Genet *Genetta angolensis* in our area (TAWIRI 2009).

The detected species seem mostly quite widespread across both study areas. No influence on any species's distribution was obvious from the proximity of Katavi NP to the west, or of village lands to the north-east. However, information was too thin to be sure no such effects exist. Direct evidence of poaching (Fig. 5) included several traps set for illegal capture of Wild Cat and genets, dispersed over Mlele BKZ. African Civet was detected more often in Rukwa GR-n despite much lower sampling effort there than in Mlele BKZ; but this species might naturally be more common in southern Rukwa GR-n because of the presence of more permanent water bodies and of more extended swamp areas (see Kingdon 1997).

Tanzania is one of few African countries with a Small Carnivore Conservation Action Plan (TAWIRI 2009). It assessed the status conservation priorities and research needs of 28 species of small and medium-sized carnivores. Our study delivers new information on the distribution of several of these species in western Tanzania, as well as some information about their threats, particularly poaching. Continued monitoring of small carnivores and other mammals in the study area is planned.

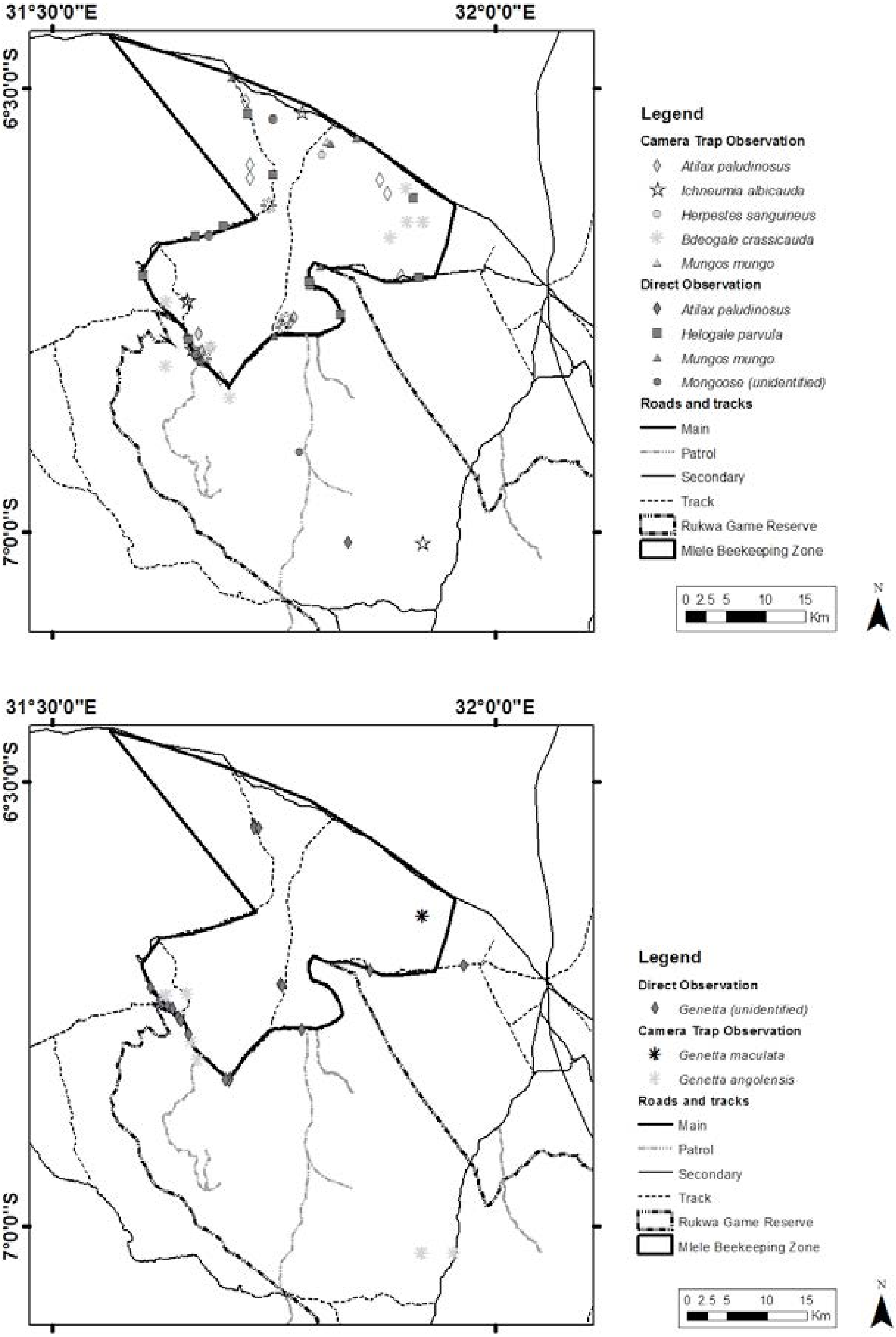
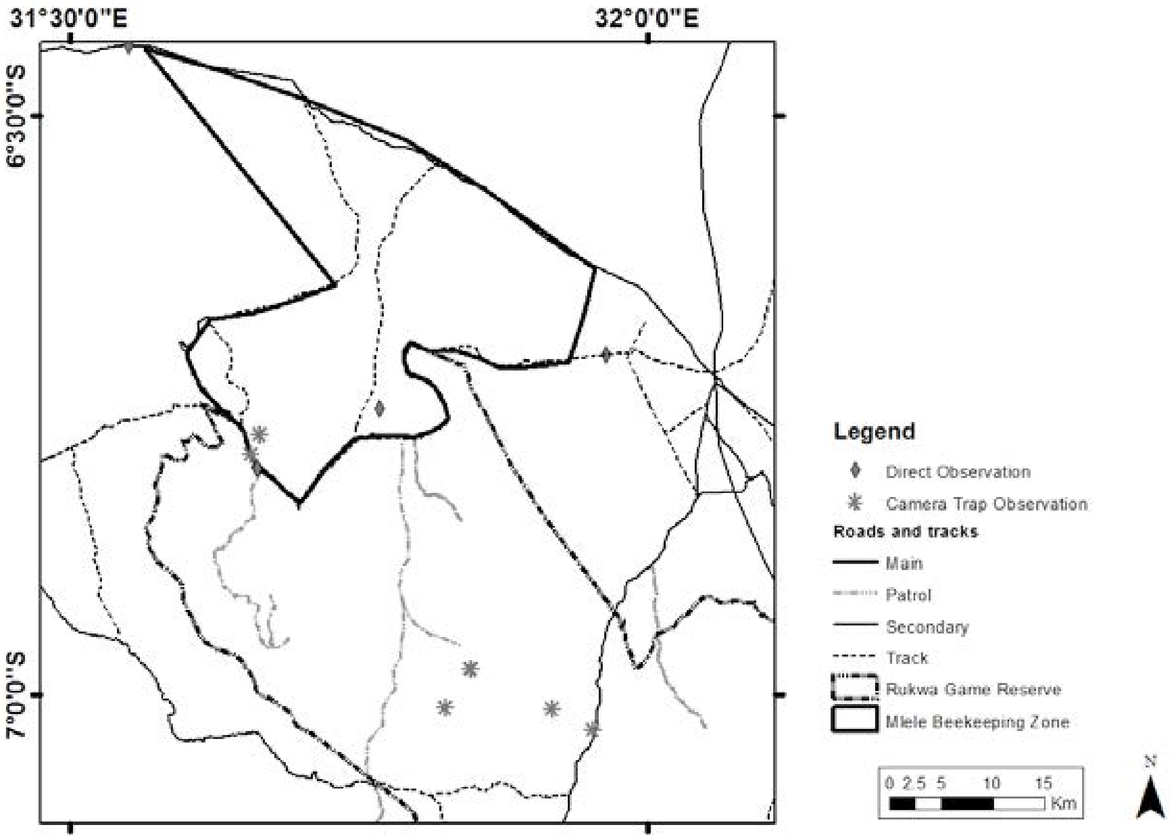


Fig. 4. Location maps of small carnivores in Mlele Beekeeping Zone and the northern part of Rukwa Game Reserve, Tanzania; (above) mongooses (Herpestidae); and (below) genets *Genetta*.



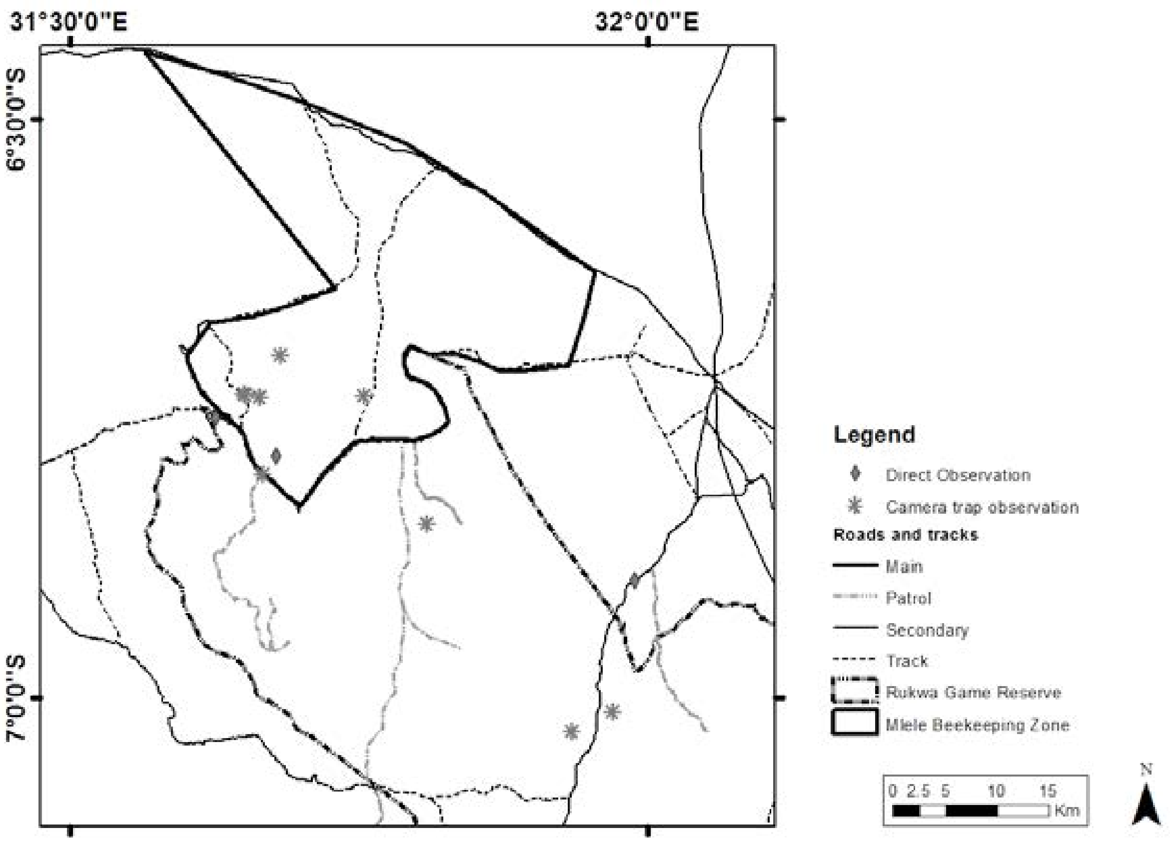


Fig. 4 (continued). Location maps of small carnivores in Mlele Beekeeping Zone and the northern part of Rukwa Game Reserve, Tanzania; (above) African Civet *Civettictis civetta*; (below)Honey Badger *Mellivora capensis*.

Fig. 5. Poaching evidence in Mlele Beekeeping Zone, Tanzania: left, a trap set up for Wild Cats *Felis sylvestris* and genets *Genetta*; right, a Miombo Genet *Genetta angolensis* killed with a spear by a poacher.

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Small carnivores of the Mt Rungwe–Kitulo landscape, southwest Tanzania: presence, distributions and threats

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Abstract

An ongoing multi-disciplinary research and conservation initiative examined the small carnivore community of the Mt Rungwe–Kitulo landscape in southwest Tanzania over an eight-year period. This key landscape's two contiguous protected areas (Mt Rungwe Nature Reserve and Kitulo National Park) had not, at the study's start, been formally managed for decades. We used sign survey, camera-trapping and interviews to assess small carnivore species richness and conservation status, and the causes of threat to each species, such as habitat degradation and hunting. Across the Mt Rungwe–Kitulo landscape 11 species of small carnivores were sighted, camera-trapped and/or recorded by hunted remains and/or signs (faeces and/or footprints). Species found in Mt Rungwe were detected also in Kitulo except for Egyptian Mongoose *Herpestes ichneumon*, which nevertheless is likely to inhabit the latter. Faeces records from 2003 to 2010 indicated broad distributions for genet(s) *Genetta* (at least some, Rusty-spotted Genet *G. maculata*), Zorilla *Ictonyx striatus* and African Striped Weasel *Poecilogale albinucha*, *Genetta* being the most commonly recorded 'species' in the landscape. Excepting Servaline Genet *G. servalina*, all species expected in the landscape were found. The recorded carnivore composition showed a prevalence of generalist species, probably resulting from the degraded habitat (and consequent invasion of the forest edge as it fragments) and a long history of hunting within the forest. Forest-dependent species are therefore at risk from isolation. Interviews demonstrated the importance of human perception and cultural values in responses to problem animal conflicts. Illegal hunting might be restraining some species' populations, particularly African Civet *Civettictis civetta* and Honey Badger *Mellivora capensis*. Local and broader conservation implications are discussed.

Keywords: habitat fragmentation, habitat use, medicinal uses, Southern Highlands

Petits carnivores de la région de Mt Rungwe–Kitulo, en Tanzanie sud-occidentale: présence, distributions et menaces

Résumé

Dans le cadre d'une recherche et d'une initiative de conservation multi-disciplinaires en cours, nous avons examiné la communauté de petits carnivores de la région de Mt Rungwe–Kitulo, au sud-ouest de la Tanzanie, sur une période de huit ans. Les deux aires protégées contiguës (la Réserve Naturelle de Mt Rungwe et le Parc National de Kitulo) de ce paysage clé, au début de l'étude, avaient été privées de toute gestion formelle pendant des décennies. Nous avons utilisé une enquête basée sur les signes de terrain, le photo-piégeage et des entretiens afin d'évaluer la richesse des espèces de petits carnivores et leur statut de conservation. En outre, nous avons étudié les causes de menace pour chaque espèce, telles que la dégradation de l'habitat et la chasse. À travers le paysage de Mt Rungwe–Kitulo, 11 espèces de petits carnivores ont été observées, prises en photo et/ou détectées par le biais de restes de chasse et/ou des indices (fèces et/ou empreintes). Les espèces trouvées au Mt Rungwe ont également été détectées à Kitulo, à l'exception de la Mangouste d'Égypte *Herpestes ichneumon*, qui est toutefois susceptible d'être aussi présente dans le parc national. Les données recueillies de 2003 à 2010 avec les excréments indiquèrent la large répartition des genettes *Genetta* (en tout cas quelques unes, comme la Genette pardine *Genetta maculata*), du Zorille commun *Ictonyx striatus* et de la Belette rayée d'Afrique *Poecilogale albinucha*, *Genetta* étant 'l'espèce' la plus couramment rencontrée dans l'ensemble de l'aire d'étude. À l'exception de la Genette servaline *G. servalina*, toutes les espèces attendues dans la région d'étude ont été enregistrées. La composition des carnivores de cette région présentait une prévalence d'espèces généralistes. Ceci est probablement le résultat de l'habitat dégradé (et de l'invasion consécutive de la lisière de la forêt au fur et à mesure qu'elle devient plus fragmentée), ainsi que d'une longue histoire de la chasse en zone forestière. Les espèces tributaires de la forêt encourent donc un risque d'isolement. Les données des enquêtes d'opinion ont démontré l'importance de la perception humaine et des valeurs culturelles dans les conflits avec les animaux qui posent problème. La chasse illégale pourrait restreindre les populations de certaines espèces, en particulier la Civette africaine *Civettictis civetta* et le Ratel *Mellivora capensis*. Les implications pour la conservation locale et en général sont discutées.

Mots clés: fragmentation de l'habitat, hauts-plateaux du sud (Tanzanie), utilisation de l'habitat, utilisations médicinales

Introduction

Throughout Tanzania environments are changing rapidly, protected ineffectively from the pressures of a growing human population. This is most obvious in areas of high human density, such as the montane highlands of the southwest. Inadequate land-use planning exacerbates the problem, as evinced by encroachment of the forests and grasslands of the Southern Highlands. Across the latter area, animal populations have been depleted (Davenport 2006, Davenport *et al*. 2008) and those still persisting are at risk of local extinction if habitat fragmentation continues unabated.

Some mammalian carnivores are particularly vulnerable to local extinction in fragmented landscapes. Their low numbers and, often, nocturnal and cryptic nature make them difficult to study and monitor. Some carnivores tend to disappear from ecosystems with many people because their protein-rich diet often draws them into direct conflict with livestock keepers, resulting in retaliatory persecution and hunting. Some are also actively pursued for their skin or body parts, for use in traditional medicine (De Luca & Mpunga 2004, 2012). These threats may limit the possibility of recovery once a population has been depleted and present conservationists with unusual and difficult challenges (Sillero-Zubiri & Laurenson 2001, Treves & Karanth 2003).

As part of an ongoing multi-disciplinary research and conservation initiative run by the Wildlife Conservation Society (WCS), we examined the carnivore community of the Mt Rungwe–Kitulo landscape in south-western Tanzania over a period of eight years. The aims were to compile a comprehensive list of carnivore species in the landscape with information on the distribution and status of each, and to assess causes of threats. The goals were to provide conservation with a tool to mitigate threats to carnivores and to design a monitoring system for these newly protected areas. This paper presents the data for carnivores excluding dogs (Canidae), cats (Felidae) and hyaenas (Hyaenidae).

Despite being poorly known previously, the Mt Rungwe–Kitulo landscape has become celebrated for the discovery of a new genus of monkey, Kipunji *Rungwecebus kipunji* (Davenport 2005, Davenport *et al*. 2008) and for the endangered orchids in Kitulo (*Bustani ya Mungu*) which are harvested for food (Davenport & Ndangalasi 2001, 2003). However, lack of management for decades (especially in forest habitats) has allowed widespread unsanctioned extraction of forest products, including illegal hunting and logging (Machaga *et al*. 2005, Davenport 2006). Habitat degradation and fragmentation are therefore commonplace and affect forest connectivity and the persistence of many forest-dependent species (Davenport 2006). That said, species that thrive in mosaics and forest-edge habitats may be benefiting from these modifications.

We present data on small carnivore diversity, distribution and encounter rate, based on camera-trapping in Mt Rungwe and the Livingstone Mountains, which latter are now included within Kitulo National Park, and on interviews and sign surveys in both Mt Rungwe and Kitulo. Information on range, altitude and habitat use by small carnivore species is presented based on data collected from 2003 until 2010 across the Mt Rungwe–Kitulo landscape. Maps generated from faecal records suggest the extent of each species's distribution. The interviews investigated the conservation status of and threats to small carnivores, including the medicinal and traditional uses of their body parts, and killing as retaliation for domestic animal attacks.

Study area: the Mt Rungwe–Kitulo landscape

On Mt Rungwe, surveys were undertaken mainly within the boundaries of the now Mt Rungwe Nature Reserve (Mt Rungwe NR). This was gazetted in 2009, having previously been a district-managed Catchment Forest Reserve. It encompasses some 150 km^2 within 9°03–12′S, 33°35–45′E (Fig. 1). We also surveyed the southern buffer area around Mt Rungwe NR and the corridor between Mt Rungwe NR and Kitulo National Park (see Results, Fig. 3). The topography varies from hilly to steeply dissected, with elevation ranging from 1,500 to 2,981 m a.s.l. at the summit (Davenport 2006). Although there is rarely a month without rain, the drier season is between June and October; the mean annual rainfall between 1968 and 2008 was 2,133 mm (Davenport *et al*. 2010). The reserve comprises montane and upper-montane forest, bamboo and montane grassland, and smaller patches of bushland and heath at higher elevations (Davenport 2006, Gereau *et al*. 2012). The surrounding human population density is 210–400 people per km^2 (Machaga *et al*. 2005), with the highest human populations being in the west along the main Tukuyu road and around the tea plantations. Water catchment properties are considered high, with water courses feeding villages and towns from Kiwira and Tukuyu to the fertile Kyela valley and hence Lake Nyasa/Malawi.

The Kitulo plateau is one of Tanzania's most important fire-climax montane grasslands. Kitulo National Park (Kitulo NP) includes the plateau and the Livingstone Forest. Kitulo NP, gazetted in 2002 (Davenport 2002a, 2002b), comprises some 273 km^2 of Afromontane and Afroalpine grassland at 2,600–2,960 m a.s.l. (Fig. 1). Located between the Kipengere Range and the Uporoto and Livingstone Mountains (9°00–16′S, 33°43′–34°03′E), Kitulo was formed over 2.5 million years ago from volcanic ash thrown out from the erupting Mt Rungwe a few kilometers to the west. Heavy rain often falls in convectional thunderstorms during one strict wet season from November to April. During the barren dry season, from May to October, nightly temperatures plummet, with frosts regular over many weeks in July and August. The resultant fertile and well-drained soils, as well as the high rainfall, temperate climate and its biogeographic location, all contribute to Kitulo being the largest and most important plateau grassland community in East Africa (Salter & Davenport 2011).

Kitulo NP and the contiguous Mt Rungwe NR are home to Kipunji and other important species including rare and restricted-range mammals (e.g. a newly discovered *Dendromus* mouse, and Africa's rarest forest antelope, Abbott's Duiker *Cephalophus spadix*; Salter & Davenport 2011) and birds (e.g. Blue Swallow *Hirundo atrocerulea*) that have contributed to Kitulo being designated as an Important Bird Area *sensu* BirdLife International (Baker & Baker 2002). Southern Reedbuck *Redunca arundinum*, Bush Duiker *Sylvicapra grimmia* and Klipspringer *Oreotragus oreotragus* are also found on the Kitulo plateau. In the 1950s the Rungwe–Kitulo landscape held African Buffalo *Syncerus caffer*, Burchell's Zebra *Equus quagga*, Common Eland *Taurotragus oryx*, African Elephant *Loxodonta africana*, Lion *Panthera leo*, Leopard *P. pardus*, Spotted Hyaena *Crocuta crocuta* and Striped Hyaena *Hyaena hyaena*: all are now either locally extinct or transient visitors. Large predators have been persecuted and mostly driven out of the Mt Rungwe–Kitulo landscape, with the exception of Leopards and very occasional Lions (De Luca & Mpunga 2004, DWDL & NEM own data).

Materials and methods

Sign surveys, camera-trapping and socio-economic interviews were employed to ascertain which species of carnivores inhab-

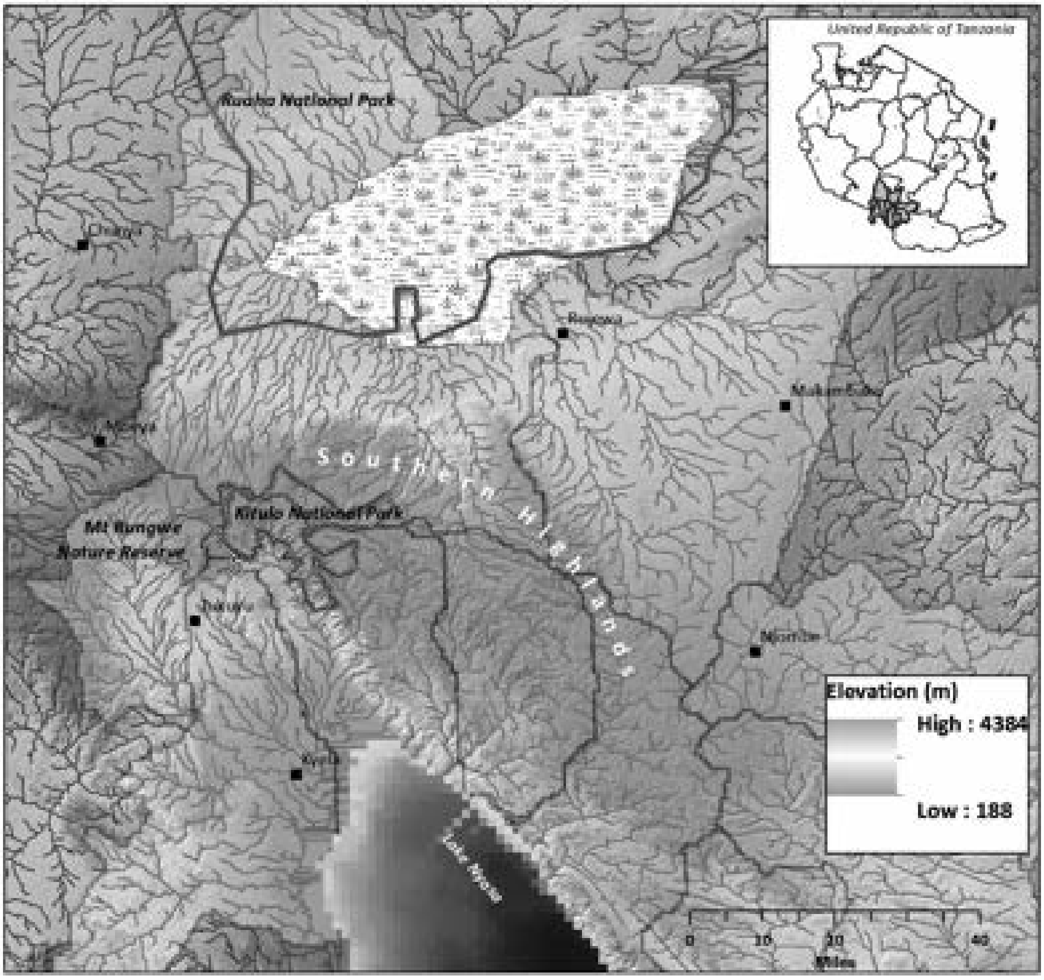

Fig. 1. The Southern Highlands in southwest Tanzania, showing the boundaries of the protected areas and river catchments (extracted from elevation data).

it Mt Rungwe–Kitulo and to investigate their status between 2003 and 2010. More detailed data on their habitats and altitude range were collected between February 2003 and December 2004 inclusive in Mt Rungwe, and during 2004 in Kitulo NP. Initial rapid assessments were carried out widely, to select appropriate sampling zones representative of all habitats and altitudes.

Ecological surveys

During all stages of fieldwork, the locations of all carnivore signs and tracks, and of all snares, loggers' huts and other human impacts, were recorded. Carnivore footprints were measured, identified and photographed. All faeces were collected for subsequent visual identification by one observer (NEM, at all times) using available field guides (Walker 1992, Stuart & Stuart 2000). Faecal identification was based on the inspection of the shape, the measurements, the colour and the food contents. Items were also compared with our reference collection of known museum specimens at the WCS office in Mbeya. The Mt Rungwe–Kitulo landscape receives the highest annual rainfall in Tanzania (Davenport *et al*. 2010), so only very rarely did we find old or dissociated faeces. These were not considered in the analysis. All sign records and camera-trap photographs were grid-referenced, using a Garmin GPS. Data on habitat type and altitude recorded in the field were fed into a Geographical Information System (GIS) (ArcView 3.2). The main survey took place from February 2003 to December 2004 in Mt Rungwe and in 2004 in Kitulo NP. From 2005 to 2010, the survey effort in Kitulo NP and Mt Rungwe varied between years and was generally lower than the initial years.

Appendix 1 shows for each transect route surveyed in Mt Rungwe in 2003 (only) and in Kitulo NP in 2004 (only) the length, the effort (i.e. the number of times it was walked), and its start, end and mean altitudes. In Mt Rungwe the mean (± SD) altitude of a transect route at its start was 1,855 ± 50 m a.s.l. (range: 1,350–1,800 m; n = 46), and 2,150 ± 400 m a.s.l. (range: 1,400–2,950 m; n = 46) at its end. In Kitulo NP, a plateau, the mean altitude of a transect route at its start was 2,500 ± 300 m a.s.l. (range: 1,700–2,850 m: n = 37) and 2,450 ± 300 m a.s.l. (range: 1,700–2,850 m; n = 37) at its end. To obtain altitude data where field records were not available, a point at each vertex of a transect route was generated, and values extracted from an ASTER GDEM Version 2 raster file. The 'VLOOKUP' function (Microsoft Excel) was used to link the transect routes to the dates they were surveyed.

In Mt Rungwe the faecal search effort was very high in 2003, 2004 and 2005 with 517 km, 461 km and 192 km, respectively. The distances walked between 2006 and 2010 ranged between 33 and 50 km. In 2003 the mean daily distance walked was 5.9 km (range, 2–8 km; 95% CI) and the total distance walked through the year was distributed over 46 different transect routes. In Kitulo NP, annual faecal searching effort ranged from 18 km of transects in 2010, and 163 km in 2005, to 381 km in 2004 (Appendix 1). In 2004 the mean daily distance walked was 6.5 km (range 2.2–16.5 km; 95% CI) and the total distance walked was distributed over 37 transect routes. The number of faeces found per species and the percentage of transect routes with faeces give some indication how common was each species in the Mt Rungwe–Kitulo landscape. The 'faecal encounter rate' was defined as the number, *n*, of faeces/10 km walked. It was beyond the scope of this study to attempt to relate population density to faecal encounter rate (see Karanth *et al*. 2003).

Habitat use analysis

Table 1 summarises the total occurrence of habitat types along the transect routes, extracted from GPS tracklogs in Mt Rungwe (2003 only) and Kitulo NP (2004 only). These were measured by using the 'Intersect' tool in Arcmap 10.0 to link the transect routes with vegetation types. The vegetation-type information was obtained from a Landcover class map that was generated from Landsat ETM+ image p169r066 (Southern Highlands of Tanzania), dated 26 September 2001 (Fig. 2). The 'Intersect' operation produced a new file that segmented all the transect routes by landcover classes. We calculated the length of each segment, using a 'calculate geometry, Length' function in ArcMap.

Following a standard approach on analysis of habitat use data (Neu *et al*. 1974), χ^2 goodness-of-fit tests were used to compare the distribution of small carnivore faeces between different habitat types with that expected assuming no selection, i.e. proportional to the availability of habitat types along the transects. In order to meet sample-size requirements for the χ^2 test (Sokal & Rohlf 1995), data were pooled for each protected area. Table 1 summarises the total occurrence of habitat types along the transect routes; in the analysis though, the habitat type frequencies were used per transect, that is they considered the number of times that each transect route was surveyed (Appendix 1). To estimate the habitat use : availability ratio (selection ratio) between the number of small carnivore faeces found and the number expected for each habitat type, only habitat types which had more that five observations were included in the analysis. Because the values of χ^2 were quite high, conclu-

Table 1. Total occurrence of habitat types along transect routes in Mt Rungwe Nature Reserve and Kitulo National Park, Tanzania.

Habitat type	Mt Rungwe, 2003 (km)	Kitulo NP, 2004 (km)
Forest Natural and Degraded	121.04	81.86
Woodland	39.69	76.17
Agriculture (All)	26.25	12.35
Grassland	12.40	127.83
Bamboo	8.41	15.67
Upper Ericaceae	4.77	9.36
Mountain Shadow	4.64	2.80
Lower Ericaceae	2.79	1.13
Cloud Shadow	2.46	0.33
Pine	2.08	2.67
Heath and Grass	1.97	0.76
Burned	0.00	4.61
Pyrethrum	0.00	0.19

Survey effort in other years is not incorporated.

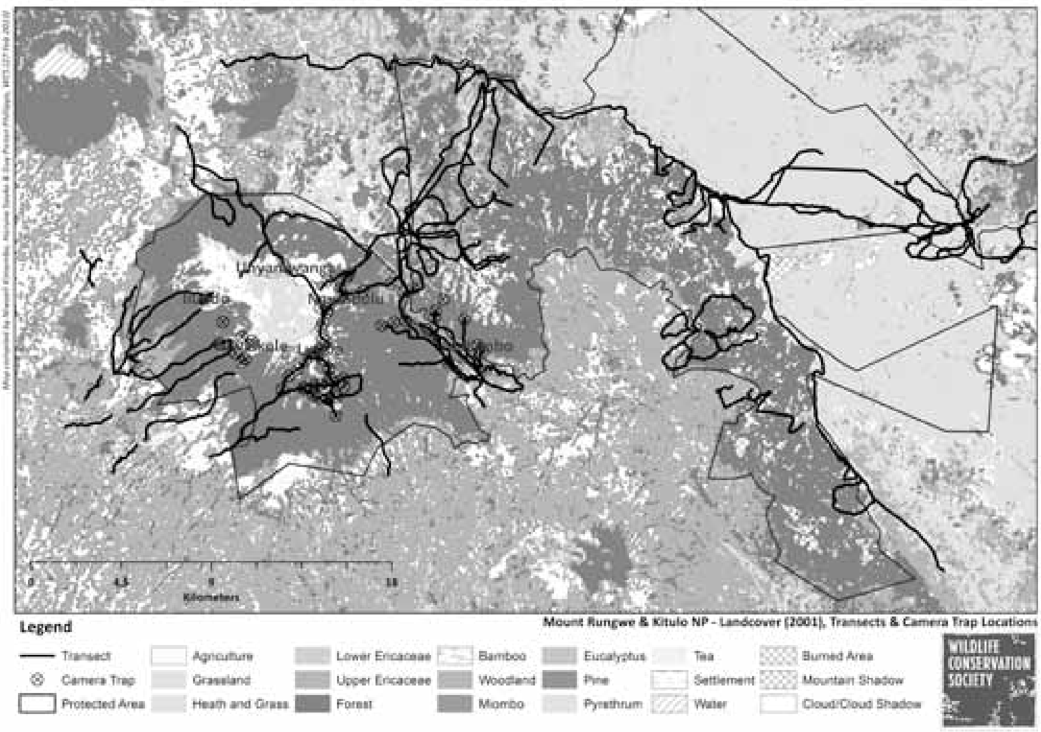

Fig. 2. Vegetation of the Mt Rungwe–Kitulo landscape, Tanzania, showing the extent of each habitat-type crossed by the transects (black line). Black rings show the camera-trap locations (around Lusiba, Mwaikole, Ilundo, Unyamwanga, Ngumbulu and Malambo) within the Mt Rungwe and Livingstone areas.

sions on habitat preference or avoidance were possible when the interval of values of observed habitat use did not overlap with the expected use values. When these intervals overlapped, there was considered to be no effect of selection or avoidance.

Camera-trapping in Mt Rungwe
Camera-trapping was conducted between February 2003 and December 2004 in six sectors in Mt Rungwe (Lusiba, Malambo, Mwaikole, Ngumbulu, Unyamwanga and Ilundo) (Fig. 2), using five passive weatherproof 35 mm Camtrak camera-traps (www.trailcam.com) and 15 weatherproof 35 mm cameras of which eight were Trailmaster TM55 passive infrared and seven were Trailmaster TM1550 active infrared (www.trailmaster.com). Camera-trap locations were concentrated along the forest edge, to document how often habitat generalists were entering forest. Locations were chosen to maximise photo-capture rates and were documented by GPS (Fig. 2). Taking into account Mt Rungwe's difficult terrain and that most carnivores tend to follow trails, most camera-traps were placed within 100 m of trails and/or near locations where faeces had previously been found. The typical distance between traps was 0.5–1 km. All traps were set to work continuously through the 24-hour cycle, with one camera-trap-night being 24 hours. They were mounted 25–30 cm above ground, assuming that large carnivore presence (which would suggest higher mounting for optimal recording) was unlikely. Cameras were programmed to print date and time on a 400 ISO film with a 1.5-minute delay between successive images. Notionally independent events were defined partly following O'Brien *et al.* (2003): namely, consecutive photographs of different conspecific individuals (no social groups were photographed) in cases where they were identifiable, and consecutive photographs of conspecifics and non-conspecifics more than one hour apart. Photographs without date and time printed were omitted from the analysis.

Information on the number of camera-trap-nights for which each camera-trap was functional was retrieved at intervals of 7–10 days. The Mt Rungwe area having intense human exploitation, camera-traps were baited to increase trapping success. Trials using a variety of baits found the most effective to be a suspended liquid blood attractant. This was routinely employed thereafter. The number of camera-trap locations in each of the six camera-trapped sectors of the Mt Rungwe–Kitulo landscape varied according to its size (Fig. 2). Cameras were usually deployed for a minimum of 21 days. Out of 82 camera-trap locations, 23% were in bamboo forest, 25.6% in grassland, 43.9% in montane forest, 4.9% in upper Ericaceae, and 2.4% in pine *Pinus* stands (Fig. 2).

Village interviews
To supplement information from camera-trapping and ecological surveys and to investigate illegal hunting, we interviewed, by structured questionnaire (Appendix 2), 126 people from six villages (Ilolo, Ilundo, Malambo, Unyamwanga, Ngumbulu, Syukula) around Mt Rungwe, between May and June 2003. Interviewees were selected based on their knowledge of the area and wider landscape. They comprised hunters and collectors of honey, firewood and medicinal plants, mostly 40–80 years old, although six were under 40. The interviews covered many issues including carnivore sightings (relating the species to a booklet of photographs), patterns of sightings by habitat-types, locations and vernacular names. People were asked when they last saw each species. Human–carnivore conflict and history of hunting activities were also ascertained. Data were collected on the frequency of problem-animal occurrences and the ways employed to prevent or reduce them. Information on carnivore exploitation such as consumptive use (traditional medicine, spiritual use) and cultural significance was gathered.

Results

Eleven small carnivore species from four families were recorded in the landscape by direct sighting, camera-trapping, pelts and/or their signs (Table 2). All species found in Mt Rungwe

Table 2. Small carnivore species of the Mt Rungwe–Kitulo landscape, Tanzania.

English name	Scientific name	Mt Rungwe	Kitulo NP
Mustelidae			
African Clawless Otter	*Aonyx capensis*	CT*,F,S	F
Zorilla	*Ictonyx striatus*	F,S	F
African Striped Weasel	*Poecilogale albinucha*	F,S	F
Honey Badger	*Mellivora capensis*	F	F
Nandiniidae			
African Palm Civet	*Nandinia binotata*	VO,CT,S	VO,F
Viverridae			
Large-spotted Genet	*Genetta maculata*	CT,VO,S,F	CT**,F,VO
African Civet	*Civettictis civetta*	F	F
Herpestidae			
Marsh Mongoose	*Atilax paludinosus*	F	F
Egyptian Mongoose	*Herpestes ichneumon*	VO,S	
Common Slender Mongoose	*Herpestes sanguineus*	CT,VO,F,S	VO,F
Banded Mongoose	*Mungos mungo*	VO	VO

CT = camera-trapped; F = faeces; S = skin; VO = visual observation.
* Faeces in 2003; camera-trap in 2010.
** Camera-trapped within the Mt Rungwe session in 2003 in the Livingstone Mountains which were later included in Kitulo NP.

were found also in Kitulo NP except for Egyptian Mongoose *Herpestes ichneumon*, although it is likely to be there too.

Mt Rungwe–Kitulo landscape faeces survey 2003–2004

Faecal encounter rates in Kitulo NP in 2004 (Table 3) suggested that the most common carnivores there were genet(s) *Genetta* (perhaps Rusty-spotted Genet *G. maculata*) and Zorilla *Ictonyx striatus*, followed by mongooses *Herpestes* (possibly Common Slender Mongoose *Herpestes sanguineus*). *Genetta*, African Striped Weasel *Poecilogale albinucha*, *I. striatus* and African Civet *Civettictis civetta* preferred mostly the cultivation matrix, but *Herpestes* mongooses showed a weaker such preference. Except for the mongoose, all the preceding species significantly selected the bamboo forest, while *Genetta* and *I. striatus* avoided the natural forest. No *P. albinucha* or *Herpestes* faeces were found in this habitat and results were not conclusive for *C. civetta* (Table 4). Only *Herpestes* preferred extensively the planted pine forest and the grassland in part; results on grassland habitat preference or avoidance for *Genetta*, *I. striatus* and *C. civetta* were inconclusive (Table 4). The altitudinal distribution of faeces found in Kitulo NP is shown in Table 5. *Genetta* faeces were found in equal numbers between 2,000–2,500 m and 2,500–3,000 m, whilst *I. striatus* and *Herpestes* (*H. sanguineus*?) faeces were found mainly between 2,500 and 3,000 m.

Table 3. Faecal encounter rates of small carnivores in Kitulo National Park, Tanzania, in 2004.

Species name[1]	Number of faeces	% routes with faeces	Faecal encounter rate[2]
Genetta[3]	186	66.70	4.52
Ictonyx striatus	126	68.25	3.06
Herpestes[3]	63	31.75	1.53
Poecilogale albinucha	32	31.75	0.78
Civettictis civetta	20	6.35	0.49
Atilax paludinosus	7	7.93	0.17
Aonyx capensis	5	4.76	0.12
Mellivora capensis	4	4.76	0.10

[1] English names are given in Table 2.
[2] Number faeces/10 km walked.
[3] Some *G. maculata* and *H. sanguineus* were identified by other methods (see text).

The faecal encounter rates in Mt Rungwe in 2003 (Table 6) suggested that the most common carnivores there were *Genetta* and African Clawless Otter *Aonyx capensis*. *Ictonyx striatus* and *Herpestes* seemed less common than in Kitulo NP, whilst *P. albinucha*, Honey Badger *Mellivora capensis*, Marsh Mongoose *Atilax paludinosus* and *C. civetta* faeces were found only rarely. In 2003 *P. albinucha* and *I. striatus* showed a high preference for the cultivation matrix, while the forest was actively avoided by *Genetta* and *P. albinucha*; *Genetta* and, less so, *I. striatus*, preferred grassland (Table 4). The altitudinal distribution of faeces found in Mt Rungwe is shown in Table 7. *Genetta* faeces were found in equal numbers within 1,500–2,000 m and within 2,000–2,500 m. Faeces of *P. albinucha* and *M. capensis* were found mainly between 2,000 and 2,500 m.

The distribution maps (Fig. 3) distinguish faeces found during 2003–2005 from those found during 2006–2010. Over 2003–2010, *Genetta* (Fig. 3a), *I. striatus* (Fig. 3b) and *P. albinu-*

Table 4. Habitat selection ratios[1] for each small carnivore species in Mt Rungwe and Kitulo National Park, Tanzania.

Species[2]	***G.***	***P. a.***	***I. s.***	***G.***	***P. a.***	***I. s.***	***H.***	***C. c.***
Habitat type	**Mt Rungwe, 2003**			**Kitulo NP, 2004**				
Agriculture		7.93 (pref.)	7.44 (pref.)	5.97 (pref.)	9.18 (pref.)	10.12 (pref.)	6.7 (pref.)	11.60 (pref.)
Bamboo				3 (pref.)	7 (pref.)	3 (pref.)		6.88 (pref.)
Forest Natural and Degraded	0.64 (avoid)	0.6 (avoid)		0.7 (avoid)		0.53 (avoid)		1.04 (nc)
Grassland	5.75 (pref.)		3.34 (pref.)	1.3 (nc)	0.92 (nc)	1.06 (nc)	1.41 (pref.)	
Heath and Grass								
Lower Ericaceae								
Pine							39.5 (pref.)	
Upper Ericaceae								
Woodland								
χ^2 value[3]	214.05 *df* = 1	61.9 *df* = 1	62.87 *df* = 1	112.67 *df* = 3	97.4 *df* = 2	326.15 *df* = 3	538.67 *df* = 2	103.00 *df* = 2
***P* value**[3]	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

[1] Number of observed faeces frequency/expected frequency per habitat type. In parentheses, conclusions on positive preference ('pref.'), avoidance ('avoid') or no effect ('nc') from analysis of observed use (see text).
[2] *G.* = Genet *Genetta* (some *G. maculata* were identified by other methods; see text); *I. s.* = Zorilla *Ictonyx striatus*; *H.*= Mongoose *Herpestes* (some *H. sanguineus* were identified by other methods; see text); *P. a.* = African Striped Weasel *Poecilogale albinucha*; *C. c.* = African Civet *Civettictis civetta*.
[3] χ^2 and *P* values from goodness-of-fit tests of observed versus expected distributions of small carnivore faeces per habitat.

Table 5. Kitulo National Park, Tanzania: altitude distribution of small carnivore faeces in 2004, and minimum and maximum altitudes where each species's faeces were found during 2004–2010.

Species[1]	**Altitude intervals (m)**			**Min. altitude (m)**	**Max. altitude (m)**
	1,501–2,000	**2,001–2,500**	**2,501–3,000**		
Civettictis civetta	12	0	7	1,990	2,550
Genetta[2]	23	86	77	1,660	2,900
Atilax paludinosus	7	1	4	1,640	2,820
Aonyx capensis	4	0	1	1,610	2,550
Poecilogale albinucha	6	9	17	1,830	2,830
Ictonyx striatus	30	38	58	1,570	2,875
Herpestes[2]	10	10	38	1,660	2,850
Mellivora capensis	4	0	0	1,635	1,945
Total number of faeces	**96**	**144**	**202**		

[1] English names are given in Table 2.
[2] Some *G. maculata* and *H. sanguineus* were identified by other methods (see text).

Table 6. Faecal encounter rate of small carnivore species in Mt Rungwe Nature Reserve, Tanzania, in 2003.

Species name[1]	**Number of faeces**	**% routes with faeces**	**Faecal encounter rate**[2]
Genetta[3]	71	45.45	1.03
Aonyx capensis	32	11.36	0.46
Ictonyx striatus	15	11.36	0.22
Herpestes[3]	15	11.36	0.22
Poecilogale albinucha	12	11.36	0.17
Mellivora capensis	6	13.64	0.09
Atilax paludinosus	5	11.36	0.07
Civettictis civetta	1	2.27	0.01

[1] English names are given in Table 2.
[2] Number faeces/10 km walked.
[3] Some *G. maculata* and *H. sanguineus* were identified by other methods (see text).

cha (Fig. 3c) seemed the most widespread species across the Mt Rungwe–Kitulo landscape. The distribution of *A. capensis* (Fig. 3e) will be reported elsewhere (De Luca *et al*. in prep.).

Camera-trapping survey

Between February 2003 and December 2004, camera-traps were set at 85 locations, within six sectors of Mt Rungwe and the Livingstone mountains part of Kitulo NP (Fig. 2). Some 31 'independent' photographs of small carnivores were recorded from 3,938 camera-trap-nights (Table 8). The highest camera-trapping rate of small carnivores was in Mwaikole, in southern Mt Rungwe (Table 8). In this southern part *G. maculata*, the most commonly photographed species of small carnivore during the survey, was photographed in Mwaikole, Malambo and Lusiba. African Palm Civet *Nandinia binotata* was photographed in Mwaikole and Malambo. *Herpestes sanguineus* was only photographed in Lusiba. No small carnivore was camera-trapped in the three northern sectors of Mt Rungwe NR: Ngumbulu, Ilundo and Unyamwanga (Fig. 2; Table 8). Lusiba in the southeast and Ngumbulu in the north of Mt Rungwe had more trap-nights per camera because of a Serval *Leptailurus serval* survey in 2004.

Direct sightings of live and dead animals

Herpestes ichneumon was sighted at the forest edge around the villages of Malambo (in Rungwe East) and Ngumbulu (in Rungwe North). A skin found was from Kibisi (in South West Rungwe). Banded Mongoose *Mungos mungo* was seen at the forest edge in Nkuka Forest (Southern Rungwe) and around the village of Ngumbulu (Rungwe North); and in Numbe Valley (North-east of Kitulo NP). *Nandinia binotata* was sighted in Nkuka Forest (Southern Rungwe) and in the Livingstone Forest, Numbe (within Kitulo NP), while a skin was seen from the Malambo area (Rungwe East). *Genetta maculata* was sighted widely within Mt Rungwe NR (18 sightings). All six genet skins

Table 7. Mt Rungwe Nature Reserve, Tanzania: altitude distribution of small carnivore faeces in 2003, and minimum and maximum altitudes where the species were found during 2003–2010.

Species[1]	**Altitude intervals (m)**			**Min. altitude (m)**	**Max. altitude (m)**
	1,501–2,000	**2,001–2,500**	**2,501–3,000**		
Civettictis civetta	1	0	0	1,517	2,471
Genetta[2]	38	38	8	1,538	2,887
Atilax paludinosus	1	1	0	1,680	2,354
Aonyx capensis	26	3	0	1,559	2,430
Poecilogale albinucha	1	7	2	1,562	2,625
Ictonyx striatus	5	4	0	1,600	2,480
Herpestes[2]	5	1	1	1,520	2,887
Mellivora capensis	1	5	0	1,617	2,390
Totals number of faeces	**78**	**59**	**11**		

[1] English names are given in Table 2.
[2] Some *G. maculata* and *H. sanguineus* were identified by other methods (see text).

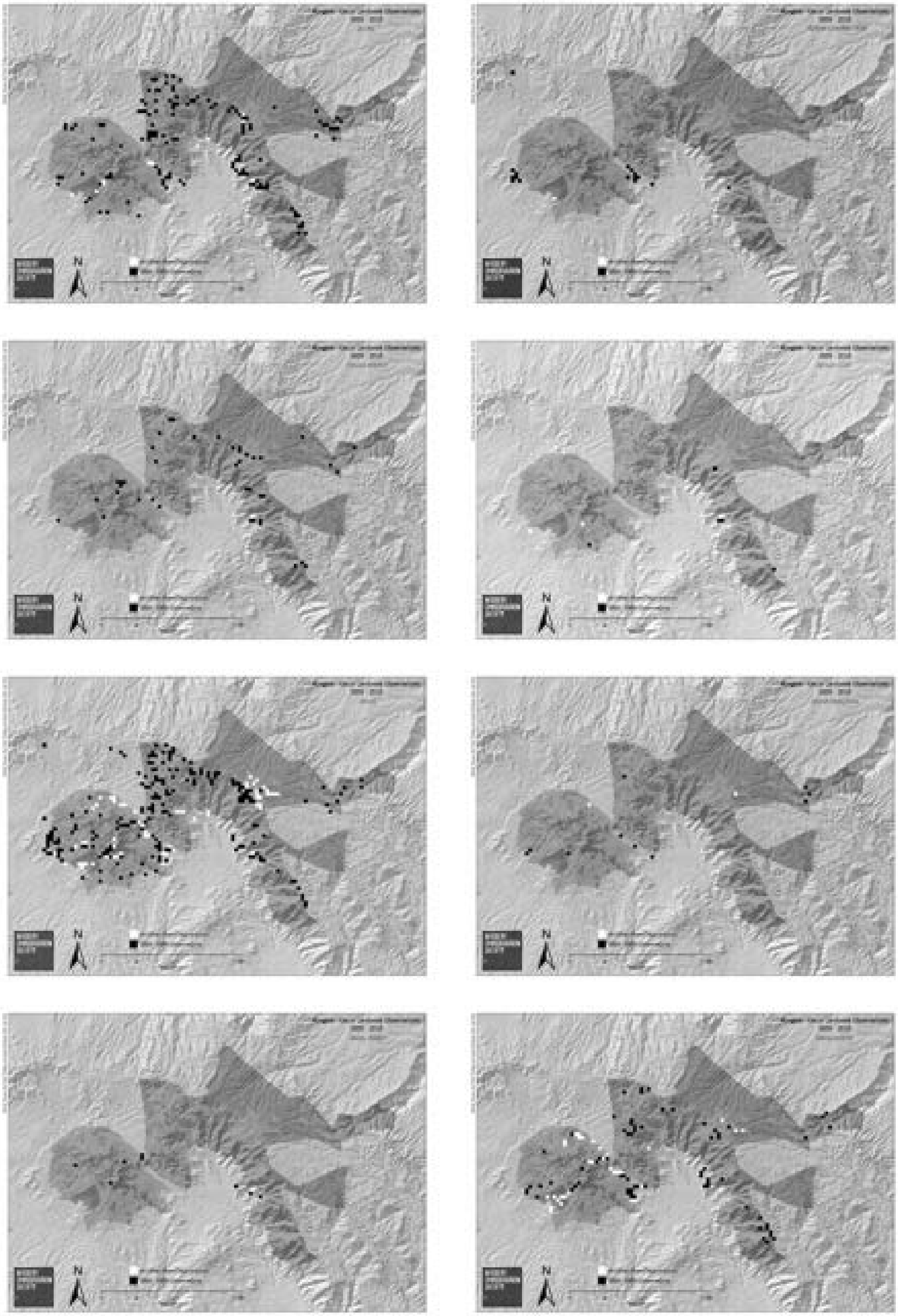

Fig. 3. Distributions of small carnivores in the Mt Rungwe–Kitulo landscape, as determined by records of faeces, in 2003–2010. (a) Zorilla *Ictonyx striatus*; (b) African Striped Weasel *Poecilogale albinucha*; (c) unidentified genet(s) *Genetta*; (d) Honey Badger *Mellivora capensis*; (e) African Clawless Otter *Aonyx capensis* (preliminary); (f) African Civet *Civettictis civetta*; (g) Marsh Mongoose *Atilax paludinosus*; (h) unidentified mongoose(s) *Herpestes*. The total coverage of survey points as background (light grey) indicates the extent of survey. The black squares indicate the faeces locations in 2003–2005. The white squares indicate faeces locations in 2006–2010. The dark grey represents the extent of the protected areas: Mt Rungwe Nature Reserve and Kitulo National Park.

Table 8. Encounter rates and the number of camera-trap locations where each of the three small carnivore species camera-trapped were recorded in six sectors of Mt Rungwe and the Livingstone mountains, Tanzania.

	Species	Mwaikole	Ngumbulu	Malambo	Lusiba	Ilundo	Unyamanga	TOTAL
Total camera-trap-nights		408	740	488	2,145	78	79	3,938
Mean number camera-trap-nights per camera-trap		31.4	52.85	40.66	48.75	78	79	330.66
Working cameras		13	14	12	44	1	1	85
Number of 'independent' photographs	*G. maculata*	5	0	5	10	0	0	20
	N. binotata	4	0	3	0	0	0	7
	H. sanguineus	0	0	0	4	0	0	4
Total of small carnivore 'independent' photographs		**9**	**0**	**8**	**14**	**0**	**0**	**31**
Number camera-trap locations where photographed	*G. maculata*	5	*	5	9	*	*	19
	N. binotata	4	*	3	*	*	*	7
	H. sanguineus	*	*	*	4	*	*	4

*No photographs were taken.
English names are given in Table 2.

Table 9. Carnivore sightings reported by villagers (n = 126) in the Mt Rungwe–Kitulo landscape, Tanzania, with habitat location and approximate years of sighting.

Species		**Habitat types**				**Period**		
	n	**Village %**	**Field %**	**Forest %**	**River %**	**2000s%**	**1990s%**	**1980s%**
Mellivora capensis	109	6.42	1.83	**90.83**	0.92	**88.07**	5.50	6.42
Ictonyx striatus	106	**88.68**	5.66	5.66	0.00	**88.68**	3.77	7.55
Poecilogale albinucha	98	**98.98**	1.02	0.00	0.00	**97.96**	1.02	1.02
Aonyx capensis	81	2.47	0.00	0.00	**97.53**	**71.60**	17.28	11.11
Civettictis civetta	80	20.00	15.00	**48.75**	16.25	**76.25**	7.50	16.25
Herpestes sanguineus	75	**94.67**	1.33	2.67	1.33	**98.67**	0.00	1.33
Genetta[1]	71	47.89	7.04	45.07	0.00	**95.77**	2.82	1.41
Atilax paludinosus	32	0.00	17.24	3.45	**79.31**	**81.25**	0.00	18.75
Herpestes ichneumon	27	**81.48**	0.00	11.11	7.41	**92.59**	7.41	0.00
Nandinia binotata	16	12.50	6.25	**75.00**	6.25	**93.75**	6.25	0.00
Mungos mungo	7	**42.86**	14.29	28.57	14.29	**100.00**	0.00	0.00

[1] Some *G. maculata* were identified by other methods; see text.
n: number of people reporting sightings.
Habitat types: % of people reporting sighting of each species in the various habitat types. Each person reported only one habitat per species.
Period: % of people reporting their last memory of sighting each species as in the 2000s, 1990s or 1980s.
The highest value for each species concerning habitat use and period of sighting is emboldened.

collected from hunters, from Ilundo (West Rungwe), and from Malambo (East Rungwe), were confirmed as *G. maculata* (P. Gaubert verbally 2012), despite their great variation in fur coloration and pattern. This was consistent with camera-trap photographs (see above). Within the rest of Kitulo NP genets were neither camera-trapped nor recorded as skins, and other genet species might thus occur. *Herpestes sanguineus* was sighted nine times close to the forest edge within Mt Rungwe NR; always close to the forest edge, near the villages of Kikondo and Usalama (both in the north of Kitulo Plateau); and near the village of Missiwa (in the south of Kitulo Plateau) (12 sightings). Two *H. sanguineus* skins were found, from Malambo (East Rungwe). The single skins of *P. albinucha* and *I. striatus* were each from the Unyamwanga area (West Rungwe).

Carnivore sightings reported by villagers in Mt Rungwe
Amongst 126 interviewees, most people reported their most recent sightings of most species to be within the previous three years; fewer people had last seen any species in the 1990s or 1980s (Table 9). The species reported by most interviewees in and around villages were *P. albinucha*, *I. striatus*, *Herpestes sanguineus* and *H. ichneumon*. *Genetta* was reportedly equally seen in the village and in the forest, while *M. capensis*, *C. civetta* and *N. binotata* were reportedly most sighted in the forest. *Aonyx capensis* and *Atilax paludinosus* were mainly reported from near rivers. Vernacular names for species collected during the interviews are presented in Appendix 3, in Kiswahili, the official Tanzanian language; Kinyankyusa, spoken widely in the area of Mt Rungwe NR; and Kinga, spoken in the area of Kitulo NP.

Threats
Are carnivores considered a problem around Mt Rungwe?
Of the 121 people (96% of those interviewed) in the villages who answered whether they considered carnivores to be a problem, 92%, 38% and 78%, respectively, considered *I. striatus*, *Genetta* and *H. sanguineus* to be problematic. Although *P.*

albinucha is considered a blessing to have around because of its perceived magical powers, the species is also considered a problem because it catches chickens. Between 11% and 24% of interviewees claimed to have seen *H. ichneumon*, *A. paludinosus* and *C. civetta* attacking poultry. Amongst the 121 respondents, 40–64% claimed that *I. striatus*, *Genetta* and *Herpestes sanguineus* attack chickens, while *P. albinucha* was reportedly sighted by 28% of interviewees destroying crops such as maize. The same number of people stated that they had seen *M. capensis* attacking beehives. The reported timing of attacks on livestock varied between species, with *I. striatus* attacking equally at all times during the 24-hr period, *Genetta* mostly by night (19h00–07h00; 61% of answers), and *Herpestes sanguineus* and *H. ichneumon* overwhelmingly by day. All people asked what they do about the attacks stated that they react by chasing with spears, sticks and dogs to kill the animals. It was unclear how often they succeed.

Carnivore hunting on Mt Rungwe

Of the 126 people interviewed, 56 (44.4%) answered about hunting. Of these 56, 41% considered that carnivore hunting occurred in the 1970s but according to 52% it did not. The respective figures for the 1980s were 48% and 50%, and for the 1990s, 21.4% and 78.6%. Finally, for the interval 2000–2003, 98% of the respondents denied the occurrence of carnivore hunting. All respondents stated that hunting was for food, with almost no hunting specifically for skins or other parts. The most common hunting methods were dogs and traps; snares and other methods were also reported. According to 83%, 64% and 50% of interviewees, *A. capensis*, *M. capensis* and *P. albinucha*, respectively, were hunted with log traps. Poison was said to be rarely employed.

Carnivore use on Mt Rungwe

It was difficult to distinguish whether animals were caught for food, medicinal/witchcraft purposes or a combination of both. Most likely is that any carnivore caught while hunting or in retaliation served both purposes. All carnivore parts used were valued for medicinal and/or witchcraft uses if not eaten, but some species had more uses than others. The scent glands of *C. civetta* are used to treat 'mental illnesses' in children (most likely to be epilepsy) and the skin to treat neck pain. People also attributed magical effects to this animal including powers of resuscitation, protection from witchcraft, and the stopping of children from crying. *Aonyx capensis* skin is used to treat neck and back pain, epilepsy, convulsions and mental illnesses in the young. Its blood is believed to increase fighting strength. Until the 1980s, members of some royal clans used to be buried in otter skins. *Genetta* skins are used to cure neck pains and mental illness, but at the same time their skins increase magical powers, and are used in fortune-telling and for protection from witchcraft. It is believed that a cow's fertility can be augmented if the cow jumps over a genet skin. Thus, most people with a cow also own a genet skin. *Mellivora capensis* skin is said to cure pains and mental trauma, the brains to treat headaches, the whole body to increase fighting abilities; its nose is used by local medicine men for various purposes. The greatest magical power of all is attributed to *P. albinucha*. Its skin is used to cure back pain, protect from witchcraft and to pay respects to the deceased; and the whole body gives the owner magical powers to steal crops, yet protects his own fields from thieves.

Discussion and conclusions

This, the first inventory of carnivores in Mt Rungwe NR and Kitulo NP, recorded 18 carnivore species (De Luca & Mpunga 2012), 11 of which were small carnivores, i.e. excluding Felidae, Canidae and Hyaenidae. The combination of ecological and sociological investigations provided a diverse list of species from the landscape, concomitant with the size, type and status of the habitat. Indeed, the diversity is perhaps surprising given the extent of long-term hunting and habitat damage from logging and encroachment.

In the Mt Rungwe–Kitulo landscape, there are two forest-associated small carnivores, *M. capensis* and *G. maculata*, that also use more open habitats (Kingdon 1997), one forest-dependent (*N. binotata*), two linked to water (*Atilax paludinosus* and *Aonyx capensis*), and one that we found predominantly around forest edge and secondary growth, *P. albinucha*. Elsewhere, this is also reported in uplands with extensive grassland (Kingdon 1997). All but three species (*N. binotata*, *A. paludinosus, A. capensis*) are habitat generalists often found near human-dominated habitats; these species tend to exploit ecotones as the forest is fragmented. However even generalists often widespread and abundant (e.g. *C. civetta* and *M. capensis*), at least in Tanzania (authors' own obs), seemed uncommon or locally rare (Figs 3d, 3f), despite, according to 90% of interviews with local people, the occurrence of *M. capensis* in the forest. Similarly, almost 50% of people interviewed mentioned *C. civetta* as encountered in the forest, but we recorded little evidence of it there or indeed elsewhere. Perhaps it is mostly in forests near villages; we did not survey village surroundings in detail. This information from Mt Rungwe and Kitulo NP is largely consistent with habitat use already reported (e.g. Kingdon 1997). Species generally not dependent on forest such as *G. maculata*, *I. striatus* and *P. albinucha* apparently avoided the forest, being recorded, at least in Mt Rungwe, mostly in grassland and the cultivated matrix, areas which are probably food-rich ecotones. The grassland in Kitulo NP can be quite disturbed by agricultural encroachment (Salter & Davenport 2011) perhaps confining these species to other habitats such as in bamboo forest, a habitat preferred by *Genetta*, *I. striatus*, *P. albinucha* and *C. civetta* (Table 4). Finally *Herpestes* (apparently *H. sanguineus*) also was recorded mostly in human-derived habitats such as the cultivated matrix and pine stands in Kitulo NP.

It is surprising that only one species of genet was recorded. Habitat analysis (Gaubert *et al*. 2006) and camera-trap records in other montane forests of Tanzania (De Luca & Mpunga 2002, Rovero *et al*. 2006) suggest that Servaline Genet *Genetta servalina* might be expected in Mt Rungwe. Because other genet species might be present, faecal records are here identified only to genus. Only methods like DNA analysis and thin-layer chromatography (Ray & Sunquist 2001) would identify genet faeces to species.

Signs of two species in the Mt Rungwe–Kitulo landscape were identified at higher altitude than they have been reported before: *P. albinucha* above 2,200 m and *I. striatus* up to 2,990 m on Mt Rungwe. Meanwhile, records of *Herpestes* (*H. sanguineus*, most likely) on Mt Rungwe up to 2,900 m, *A. paludinosus* at 2,800 m and *N. binotata* at 2,300 m all corroborate these species' ecological adaptability.

Of the 11 small carnivore species recorded on Mt Rungwe, those not captured by camera-trap probably are either localised and occur where we did not place traps (see Fig. 2) such as around villages and along rivers, or are rare and thus more likely to be found by longer-lasting camera-trapping surveys. The mustelids (excepting otters), *C. civetta* and *Atilax paludinosus* were recorded only by skins and faeces. There were too few camera-traps along rivers to ensure photographs of *Aonyx capensis* (or *Atilax paludinosus*) in this study, but *A. capensis* was camera-trapped later (De Luca *et al*. in prep.). Camera-trapping did record, but gave an unrealistic distribution of, one of Africa's most common mongooses, *H. sanguineus*: substantial effort generated just four pictures, but direct sightings (Fig. 3h) suggested it was common, as did village reports and widespread records of faeces probably of this species. The camera-trapping recorded three species of small carnivores out of the 11 that could have been photographed during the 3,938 trap-nights, indicating its limitations as a sole tool for monitoring mammalian carnivores (Tobler *et al*. 2008).

Nevertheless camera-traps can record species rarely observed directly (Rovero *et al*. 2005) or clarify the range of potentially threatened species (De Luca & Mpunga 2002, De Luca & Rovero 2006). Here, camera-trapping confirmed *N. binotata* in the Mt Rungwe–Kitulo landscape, as well as a skin being found; it has subsequently been observed several times on Mt Rungwe (T. Davenport verbally 2008). Large survey effort is needed to register some species (e.g. Tobler *et al*. 2008), such as those at very low densities (Nichols & Karanth 2002), so investigators must evaluate according to each study's aim and conditions, the relative merits of long-term camera-trapping with many traps, regular sign transects, a combination of these, or other methods.

Interviews suggested that the small carnivore encountered by most people is *M. capensis*, followed by *P. albinucha*. More than 50% of interviewees claimed to have seen most of the species listed including *C. civetta*. Only 13% of interviewees claimed to have seen *N. binotata*, although it may have been under-recorded because of its nocturnal and arboreal habits.

Threats and conservation

Many people perceived small carnivores as problematic, especially *I. striatus* and *Genetta*, because they attacked free-ranging chickens. The number of chickens kept per person in each village averages only between 1 and 3.7. Chickens are not a primary source of protein, but are valued for special occasions. Thus, material damage inflicted by small carnivores is not substantial but the cultural importance attached to the ownership of chickens affected people's perception, and therefore the likelihood of retaliation. Similarly, *P. albinucha*, despite being seen as a problem animal, was tolerated somewhat because of its perceived magical powers, although was still killed for use of its body parts. Local beliefs were responsible for the great number of *P. albinucha*, *C. civetta* and *A. capensis* reportedly killed in the past, according to interviews.

Civettictis civetta is one of the most common and widespread small carnivores in Africa (Ray *et al*. 2005), and was widely reported by local people (Table 9). However, we did not camera-trap it, and found its signs only rarely: a few faecal records within the PAs, and a few latrines near village areas close to PA boundaries. Investigation of the species's current local status is warranted, because the high percentage of interviewees reporting it might be based on a few animals scavenging at village rubbish-dumps. Interviewees reported that *C. civetta* was highly hunted in the past for the valuable musk produced in the anal gland. Apart from *Aonyx capensis*, this species had the lowest proportion of sightings in the 2000s among people who had sighted it at all (Table 9): it may thus recently have been more widely distributed than at present. Its catholic diet allows *C. civetta* to survive close to human-dominated environments but it seems to require thick cover near watercourses (Kingdon 1997), which might have decreased in heavily degraded forest. Intense hunting pressure, heavy selective logging, and increased habitat fragmentation all might keep population densities low.

African Clawless Otters (for their skins), African Striped Weasels (for their 'magical' powers) and Honey Badgers (for their considerable impact on beehives: see Begg & Begg 2002), have been persecuted or hunted extensively over time across Mt Rungwe–Kitulo, as suggested by the low number of faeces found (Fig 3). *Aonyx capensis* and *P. albinucha* both have relatively short spans of reproduction (Kingdon 1997, Weigl 2005), while *M. capensis* has a low annual birth rate (Begg *et al*. 2005, Weigl 2005). These attributes make them more vulnerable than otherwise similar species to over-harvesting, and may inhibit population recovery after exposure to over-harvesting or to any other cause of high mortality. Only detailed study could ascertain whether this is the case in Mt Rungwe. However, *A. capensis* turns out to be more abundant than previously expected, especially at lower altitudes, outside Mt Rungwe Nature Reserve (De Luca *et al*. in prep.).

Heavy illegal hunting during 1960–2000 (before the start of conservation management, in 2002) coupled with increasing habitat fragmentation by fire and illegal logging (Davenport & Patterson 2002, Machaga 2009) might have compromised small carnivores' and other mammals' opportunities of immigration into, or re-colonisation of, the affected areas. In Mt Rungwe, the species with narrower habitat-use are at risk of isolation and thus local extinction. The forest/grassland corridor that connects Mt Rungwe to Kitulo has been severely degraded (Davenport 2006) but remains vital for preventing isolation of the Mt Rungwe carnivores and other animals. There are grounds for optimism, with the recent establishment of Mt Rungwe as a Nature Reserve and the collaboration of Tanzania National Parks in Kitulo.

Fuller survey and long-term monitoring of these species across the whole Mt Rungwe–Kitulo ecosystem would further clarify their conservation status and needs. Even so, it seem already clear that the sources of human disturbances like fire, hunting, illegal logging and charcoal burning in the area need to be much reduced.

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Appendix 1. Transect length, effort (total km walked), and starting, ending and mean altitudes, in Mt Rungwe Nature Reserve (2003 only) and Kitulo National Park (2004 only), Tanzania.

Transect name	Transect length (km)	Total effort (km)	Start altitude (m)	End altitude (m)	Mean altitude (m)
Mt Rungwe					
Bamboo–Peak	4.82	33.72	2,419	2,943	2,681
Dry Lake–East Ward	4.29	4.29	2,368	2,372	2,370
Dry Lake–Peak/Crater	5.56	11.12	2,799	2,359	2,579
Ilundo–Mwaikole	6.90	6.90	1,539	2,019	1,779
Ilundo area	4.65	4.65	1,584	2,062	1,823
Ilundo East	1.73	1.73	1,400	1,455	1,427.5
Ilundo–Forest 1	8.50	8.50	1,540	2,132	1,836
Ilundo–Forest 2	1.94	1.94	1,691	1,759	1,725
Ilundo–Ndaga	5.08	5.08	1,539	1,825	1,682
Ilundo West Forest	1.21	2.42	1,617	1,622	1,619.5
Kabale–Lusiba	3.47	3.47	1,532	1,878	1,705
Kabwe Area	0.69	0.69	1,563	1,576	1,569.5
Katalalifu River	2.30	2.30	1,343	1,414	1,378.5
Kipoke River	2.67	2.67	1,354	1,411	1,382.5
Lake Lusiba–Rungwe Peak	4.94	4.94	2,151	2,943	2,547
Lower Camp–Dry Lake	3.35	3.35	2,147	2,359	2,253
Lower Camp–Lusiba	3.69	3.69	2,147	2,147	2,147
Lower Malambo–Forest	4.40	39.59	1,722	2,169	1,945.5
Lower Malambo–Livingstone 1	3.79	34.10	1,753	1,976	1,864.5
Lower Malambo–Livingstone 2	5.13	5.13	1,789	1,963	1,876
Lower Malambo–Jembajemba	2.12	2.12	1,722	1,777	1,749.5
Lower Malambo–Kapela	1.92	1.92	1,722	1,846	1,784
Lower Malambo–Ngumbulu	7.29	7.29	2,223	1,711	1,967
Lower Malambo–Upper Malambo	3.81	3.81	1,692	1,974	1,833
Lower Malambo–West Ward	2.55	5.09	1,722	1,911	1,816.5
Mwaikole–Mission	6.88	55.00	1,440	2,019	1,729.5
Mwaikole via Volcanic Stone	6.81	6.81	1,438	1,981	1,709.5
Mwatisi River	3.23	3.23	1,712	1,911	1,811.5
Ndala River	3.23	3.23	1,689	1,909	1,799
Ngumbulu–Peak/Crater	9.29	18.59	2,215	2,943	2,579
Ngumbulu–Livingstone	7.14	7.14	2,218	2,372	2,295
Syukula–Peak/Crater	8.19	8.19	1,622	2,944	2,283
Syukula–Dry Lake	6.78	33.90	1,681	2,359	2,020
Syukula–Lupoto	3.81	3.81	1,706	2,002	1,854
Syukula–Lusiba	7.19	7.19	1,704	2,151	1,927.5
Syukula–Rungwe Way	6.86	6.86	1,618	2,599	2,108.5
Trap check at Ngumbulu	6.23	74.80	2,197	2,740	2,468.5
Unyamwanga–Mbeye One	6.85	6.85	1,936	1,992	1,964
Unyamwanga–Ngumbulu	6.92	13.84	2,287	2,222	2,254.5
Unyamwanga–Ntokela	11.68	11.68	1,989	2,634	2,311.5
Unyamwanga–Peak/Crater	7.55	15.09	2,342	2,944	2,643
Upper Camp–Lusiba	2.37	18.96	2,453	2,147	2,300
Upper Camp–Peak	3.36	3.36	2,147	2,887	2,517
Upper Malambo–Livingstone	2.29	2.29	1,975	1,941	1,958
Upper Malambo–Mzee Samson	6.46	6.46	1,908	2,217	2,062.5
Upper Malambo inside the forest	2.32	9.26	1,957	2,183	2,070
Kitulo NP					
Kitulo Plateau 1	14.38	14.38	2,788	2,538	2,663
Kitulo Plateau 2	18.67	18.67	2,615	2,713	2,664
Kitulo Plateau 3	14.98	14.98	2,454	2,846	2,650
Kitulo Plateau 4	5.28	5.28	2,538	2,572	2,555
Livingstone East 1	3.80	3.80	2,838	2,490	2,664

Transect name	Transect length (km)	Total effort (km)	Start altitude (m)	End altitude (m)	Mean altitude (m)
Livingstone East 2	4.98	4.98	2,739	2,409	2,574
Livingstone East 3	6.46	6.46	2,839	2,755	2,797
Livingstone East 4	6.27	6.27	2,856	2,642	2,749
Livingstone East 5	5.54	5.54	2,838	2,781	2,809.5
NE Livingstone Near Usalama 1	2.96	5.92	2,570	2,860	2,715
NE Livingstone Near Usalama 2	4.65	4.65	2,501	2,824	2,662.5
North East 1	6.02	6.02	2,563	2,867	2,715
North Livingstone 1	20.15	20.15	2,313	2,650	2,481.5
North Livingstone 2	5.92	5.92	2,420	2,634	2,527
North Livingstone 3	16.72	16.72	2,657	2,183	2,420
North Livingstone 4	7.96	7.96	2,304	2,571	2,437.5
Numbe 1	9.62	9.62	2,535	2,490	2,512.5
Numbe 2	3.61	3.61	2,594	2,487	2,540.5
Numbe 3	7.55	7.55	2,445	2,537	2,491
Numbe 4	11.25	22.51	2,571	2,556	2,563.5
Numbe 5	9.62	9.62	2,541	2,726	2,633.5
Numbe 6	9.50	9.50	2,558	2,604	2,581
Numbe 9	11.71	11.71	2,571	2,587	2,579
South East 1	16.46	16.46	2,787	2,332	2,559.5
South East 2	7.24	7.24	2,337	2,289	2,313
South East 3	6.48	6.48	2,579	2,583	2,581
South East 4	4.85	4.85	2,579	2,597	2,588
South East 5	4.75	4.75	2,570	2,596	2,583
South West 1	4.67	4.67	1,707	1,928	1,817.5
South West 2	2.10	2.10	1,706	1,885	1,795.5
South West 3	6.70	6.70	2,753	1,826	2,289.5
South West 4	17.13	17.13	2,694	2,334	2,514
West Livingstone 2	10.12	10.12	1,911	1,782	1,846.5
West Livingstone 3	14.66	29.32	2,428	2,228	2,328
West Livingstone 4	10.67	21.33	2,291	2,247	2,269
West Livingstone 5	16.38	16.38	2,218	2,170	2,194
West Livingstone 7	5.88	11.76	1,698	1,687	1,692.5

Mt Rungwe Nature Reserve and surrounds (*n* [the number of transect routes] = 46); Kitulo National Park in 2004 (*n* = 37). Survey effort in other years is not incorporated.

Appendix 2. Interview questionnaire.

Interview N. Date

Village name……………………………………GPS location……………………………………………….

1) Name of respondent:………………………………1.1) Tribe…………………………………

2) Age: 2.1) Were you born here ? 2.2) If not, when did you arrive?

3) Do you keep livestock? y/n

3.1) which one?

3.2) how many?

4) Show the animal picture in the booklet and ask the questions:

ID N.	English	Kiswhaili	Kinyachusa/ Kikinga	Seen in Rungwe? (y/n)	Where? Habitat type/ name of location	What time of the day?	When? Year (00s, 90s, 80s)	Season?	N. of ind?	Activity of animal
1	African Clawless Otter	Fisi Maji Kubwa								
2	Zorilla	Kicheche								
3	Striped Weasel	Chororo								
4	Ratel (Honey Badger)	Nyegere								
5	Large Spotted Genet	Kanu								
6	Servaline Genet	Kanu								

7	African Civet	Fungo								
8	African Palm Civet									
9	Egyptian Mongoose	Nguchiro								
10	Common Slender Mongoose	Nguchiro?								
11	Banded Mongoose	Nkuchiro								
12	Marsh Mongoose	Nguchiro wa Maji								

RISK PERCEPTION and problem animals

5.1) Is wildlife bothering the people of the village? y/n
5.2) Why?
5.3) Is any of the following species a PROBLEM?

Genet
Zorilla
Striped Weasel
Common Slender Mongoose
Banded Mongoose
Egyptian Mongoose
African Clawless Otter
Ratel
Others

If YES, when do they attack? Night/Evening/Afternoon/Morning
Do people use some protection measures against problem animals?
What do they do?

HUNTING PRESENT AND PAST

7.1) Do villagers use to hunt in the area of Mt Rungwe? Yes/No
7.1.1) When?
7.2) What were the most common species hunted?
7.3) Do villagers hunt now? Yes/No
7.4) Do villagers hunt for? Food/Culture/tradition/trade/business
7.5) Are the hunters coming from outside your village? Yes/No
7.6) If they do, do hunters coming from outside hunt for? Food/Culture/Tradition/ Trade/Business
7.7) Do villagers hunt to sell the skin of the animal or the body parts? Y/N

CONSUMPTIVE USE OF CARNIVORE PARTS

8.1) Do people use the parts of carnivores for local medicines?
8.2) Which carnivores people prefer?
8.3) What part do people use?
8.3a) And what for?
8.4) Is it easy to catch?
8.5) How do they hunt them?
8.6) When is the best time to hunt them?
8.7) Do you know anybody that knows how to catch it?
8.8) Do they catch it often? One per week, one per month, 1 per 6months/ 1 per 12months.

Appendix 3. Vernacular names of small carnivore species collected around Mt Rungwe NR in 2003*.

English Name	Species	Kiswahili	Kinyakyusa	Kinga
Zorilla	*Ictonyx striatus*	Kicheche	Mole	Ekenyelechi
African Striped Weasel	*Poecilogale albinucha*	Chororo	Inyagisi	-
Cape Clawless Otter	*Aonyx capensis*	Fisi maji	Mbago	-
Honey Badger	*Mellivora capensis*	Nyegere	Mbukula	Amadunungu
African Palm Civet	*Nandinia binotata*	Fungo	Efungo	Lifungo lyamwinyasi
Large-spotted Genet	*Genetta maculata*	Kanu	Lwengwe	-

English Name	Species	Kiswahili	Kinyakyusa	Kinga
African Civet	*Civettictis civetta*	Fungo	Efungo	Lifungo lyamwinyasi
Marsh Mongoose	*Atilax paludinosus*	Nguchiro wa Maji	Nsyesyi / Ngalang'asa	Kimwelelo
Egyptian Mongoose	*Herpestes ichneumon*	Nguchiro	Isanga	Kimwelelo
Common Slender Mongoose	*Herpestes sanguineus*	Nguchiro	Nsyesyi / Ngalang'asa	Kimwelelo
Banded Mongoose	*Mungos mungo*	Nguchiro	Nsyesyi / Ngalang'asa	Kimwelelo

*Information from 126 interviewees.

Home range and movement patterns of African Civet *Civettictis civetta* in Wondo Genet, Ethiopia

AYALEW Berhanu, AFEWORK Bekele and Mundanthra BALAKRISHNAN*

Abstract

Radio-telemetry was used to investigate the home range, movements and activity patterns of African Civet *Civettictis civetta* in Wondo Genet, Ethiopia, during November 2006–June 2007. Home-range size was calculated using the minimum convex polygon method (MCP). The home range of a sub-adult female was 0.82 km^2 (100% MCP) and 0.8 km^2 (95% MCP). The home range of an adult male was 0.74 km^2 (100% MCP) and 0.71 km^2 (95% MCP). For the two animals, average values of 2.8 km/day, 0.24 km^2, 30%, 3,590 m of travel route/km^2 and 326 m/h were recorded for daily movement distance, daily movement range, percentage of daily movement range in relation to total home range, intensity of movement and speed of Civets, respectively.

Keywords: activity patterns, intensity of movement, modified habitat, radio-tracking

Domaine vital et patrons de déplacement de la Civette d'Afrique *Civettictis civetta* à Wondo Genet, en Ethiopie

Résumé

Nous avons utilisé la radio-télémétrie pour étudier le domaine vital, les déplacements et les patrons d'activité de la Civette d'Afrique *Civettictis civetta* à Wondo Genet, en Ethiopie, de novembre 2006 à juin 2007. La taille du domaine vital a été calculée en utilisant la méthode du polygone convexe minimum (PCM). Le domaine vital d'une femelle sub-adulte s'élevait à 0,82 km^2 (100% PCM) et 0,8 km^2 (95% PCM). Le domaine vital d'un mâle adulte s'élevait à 0,74 km^2 (100% PCM) et 0,71 km^2 (95% PCM). Pour les deux animaux, des valeurs moyennes de 2,8 km/jour, 0,24 km^2, 30%, 3'590 m de route de déplacement/km^2 et 326 m/h ont été enregistrées pour la distance journalière de déplacement, le domaine journalier de déplacement, le pourcentage du domaine journalier de déplacement par rapport à la taille totale du domaine vital, l'intensité de déplacement et la vitesse des Civettes, respectivement.

Mots clés: habitat modifié, intensité de déplacement, patrons d'activité, radio-pistage

Introduction

The behaviour and ecology of African Civet *Civettictis civetta* are poorly known because of its elusive nature. African Civets are terrestrial, nocturnal and solitary, and are only usually seen in groups of two or more individuals during the breeding season and the post-den mother-young associations (Kingdon 1997, Jennings & Veron 2009). A radio-tracking study in the Bale Mountains National Park, Ethiopia, revealed that the home range of a sub-adult male (body weight 8.75 kg) was 11.1 km^2, with a core area of 0.4 km^2 (Admasu *et al*. 2004). This individual preferred to rest during the day in dense bushy vegetation; during the night, it was mainly found in *Hagenia* or juniper *Juniperus* forest, and less frequently in bush, grassland and farmland (Admasu *et al*. 2004). The aim of the present study was to determine the home-range size, movement patterns and activities of African Civets in Wondo Genet, southern Ethiopia.

Study area

Wondo Genet is located in the southeastern escarpment of the Ethiopian Great Rift Valley (7°06–07′N, 38°37′–42′E), approximately 260 km south of Addis Ababa (Fig. 1). The altitude ranges from 1,800 to 2,580 m a.s.l. The average yearly rainfall is 1,210 mm, with a rainy season during March to September, and a relatively dry period from December to February. The average annual temperature is 20°C. The study area comprised 897 ha of natural and plantation forests, farmland and human settlements (Fig. 2). The remnant forest vegetation is dry Afro-montane and is dominated by *Cordia africana*, *Albizia gummifera*, *Croton macrostachys*, *Ficus*, *Celtis africana* and *Milletia ferruginea* (Yirdaw 2002). Several cash crops are grown in the plantation areas, such as *Saccharum*, *Coffea arabica* and *Catha edulis*. Exotic plant species such as *Grevillea robusta*, *Pinus patula*, *Eucalyptus* and *Cupressus lusitanica* occupy the plantation forest.

Methods

Trapping and collaring

African Civets were captured using locally available leg-hold traps baited with meat and Avocado *Persea americana* fruit. Two to four traps were set up for a month in February 2007, around a single civetry (a communal latrine) around 18h00, and were removed early in the morning before sunset (around 06h00). The traps were checked once every two hours until dawn.

While at the trap, each Civet was anaesthetised intramuscularly with ketamine HCl (0.7 ml/kg body weight; see Jennings *et al*. 2006), using a hand-held 10 ml syringe. The sex was identified and the age approximately determined based on body size. A radio collar was attached around the neck

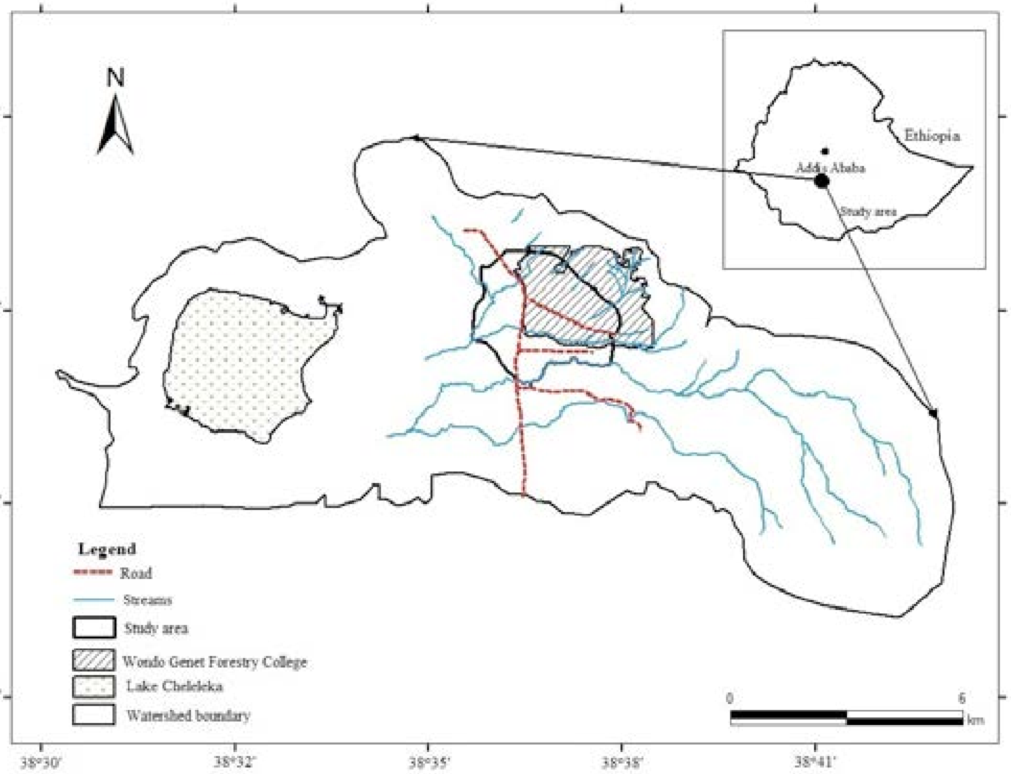

Fig. 1. Wondo Genet watershed area, Ethiopia, showing the area in which African Civets *Civettictis civetta* were studied.

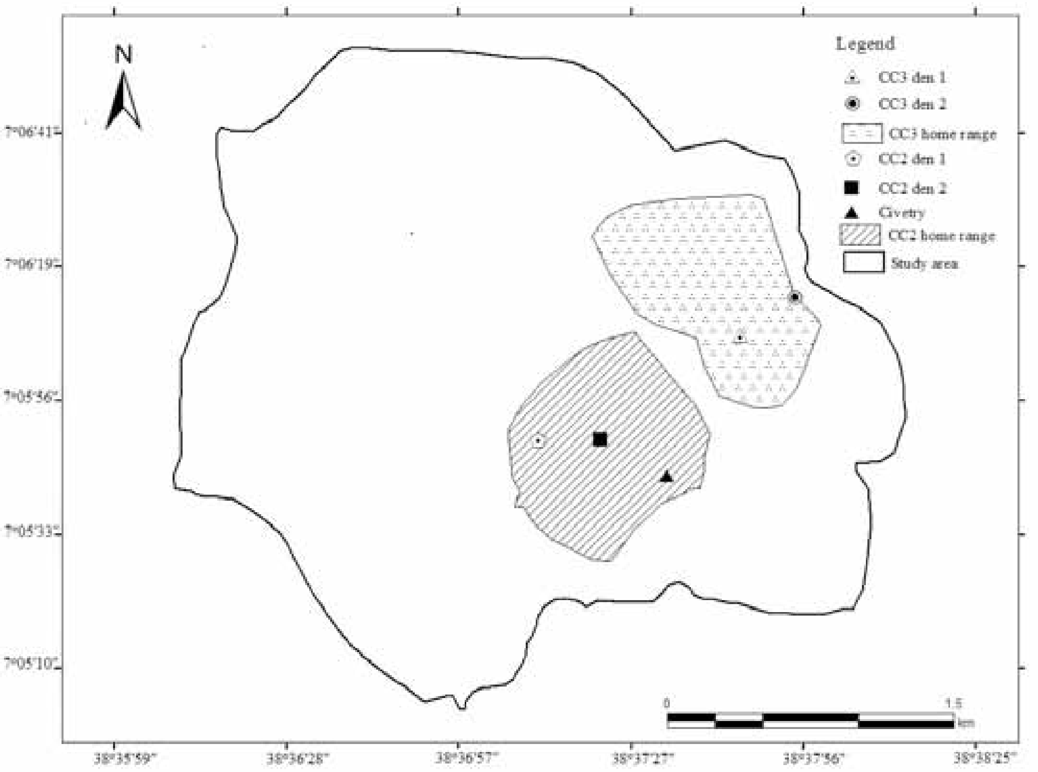

Fig. 2. Home range of the radio-collared sub-adult female (CC2) and adult male (CC3) African Civets *Civettictis civetta* in Wondo Genet, Ethiopia.

(MOD-225, Telonics, Mesa, Arizona, USA). The overall weight of the collar with transmitter was 160 g, which was less than 5% of the total body weight of the Civet. Each Civet was released in the same area where it was trapped.

Radio-tracking and data analysis

Each collared Civet was radio-tracked using a hand-held 3-element Yagi antenna (RA-14, Biotrack, UK) and a receiver (TR4, Telonics, Mesa, Arizona, USA). Radio-collared animals were followed on foot and locations were recorded using a GPS unit (Garmin 12, etrex, 1200E, Kansas, USA). Locations were obtained by triangulation from three successive bearings. A maximum of five minutes between successive bearings was used in order to minimise location errors from the animal's movement (see Jennings *et al*. 2006). Location fixes were imported into ArcGis 9.1 for home-range analysis and home-range sizes were calculated using the minimum convex polygon method (MCP), with 100% and 95% of all fixes. The radio-collars lacked activity sensors, so activity (as opposed to rest) was inferred from the important variations in radio-signal intensity, distance and direction. Whenever possible our diagnosis was confirmed by approaching the target Civet to a distance of 30–40 m, without disturbing it, and determining its state visually by means of a night-vision scope.

To record movement patterns, each animal was followed over a continuous period of 6–10 hours during the night. Between locations, 40–45 minute intervals were maintained. A distance of at least 30–100 m from the focal animal was maintained to avoid disturbance (see Colón 2002). Ten tracking sessions were carried out for each Civet; the two animals were tracked on different days. Data were analysed to provide the following parameters (Schmidt *et al*. 2003): (1) Daily movement distance (DMD): the sum of straight-line distances between consecutive locations; (2) Daily movement range (DMR): the area encompassing the daily movement route; (3) Daily movement range as a percentage of total home range (DMR% = DMR/THR, where THR is total home range of the Civet during the entire study period; (4) Intensity of movements (IM): length of the route the Civets moved per 1 km^2 of their total home range per day calculated as DMD/THR (IM indicates whether the daily routes were concentrated or loosely distributed); and (5) Speed of travel (distance moved per hour). In addition, daytime resting sites were located three times per day: at around 10h00, 14h00 and 18h00.

Results

Home range size and use

Two African Civets were captured and radio-collared: a sub-adult female and an adult male (Table 1). Data were collected within February–June 2007 for the female, and within March–April 2007 for the male. A total of 252 location fixes (203 for the sub-adult female and 49 for the adult male) were recorded. The home range of the sub-adult female was 0.82 km^2 (100% MCP) and 0.8 km^2 (95% MCP). The home range of the adult male was 0.74 km^2 (100% MCP) and 0.71 km^2 (95% MCP). There was no overlap between the ranges of the two tagged Civets (Fig. 2). The home range of the sub-adult female was concentrated around the human settlement and sugarcane farm, whereas that of the adult male was centred around the headquarters and student dormitory area.

Table 1. Details of the two African Civets *Civettictis civetta* radio-collared in Wondo Genet, Ethiopia.

Age	Sex	Weight (kg)	Capture site	Capture time	Capture date
Sub-adult	F	8.7	EF	04h49	9 February 2007
Adult	M	14	NF	23h50	27 February 2007

EF = *Eucalyptus* forest, NF = Natural forest

Table 2. Movement parameters of the two African Civets *Civettictis civetta* radio-collared in Wondo Genet, Ethiopia.

Parameters*	Sub-adult female	Adult male
DMD (km)	3.22±0.27 (2.29–4.24)	2.4±0.55 (1.33–3.15)
DMR (km^2)	0.31±0.04 (0.2–0.42)	0.17±0.04 (0.1–0.23)
DMR%	38.3±4.4 (24.4–51.2)	23.0±5.2 (13.5–31.1)
IM (m/km^2)	3,928±326 (2,797–5,175)	3,247±744 (1,795–4,255)
Speed (m/h)	345±28 (447–235)	307±82 (166–450)

*DMD = daily movement distance, DMR = daily movement range, DMR% = daily movement range as a percentage of the total home range, IM = intensity of movement. Tabled values are mean ± SE (range). Both animals were tracked for 10 nights.

Movement patterns

Table 2 presents the movement patterns of each collared Civet. The average daily distance moved was 2.8 km (range: 1.3–4.3 km). The sub-adult female's mean daily area coverage was 0.31 km^2, that of the adult male only 0.17 km^2. The daily movement as a percentage of the (total) home ranges averaged 30%, larger in the sub-adult female than in the male. High intensity of movement was observed in both individuals, with an average of 3,590 m of travel route/km^2. The average speed was 326 m/h (range: 167–450 m/h).

Activity patterns

There was no continuous monitoring of Civet activity between 06h00 and 18h30. Civets were active throughout the night from about 19h00 (after sunset), with the highest activity period during 20h30–06h00 (before sunrise). There was neither sign of resting in the middle of the night nor of any return to the den site during the night (Fig. 3). Nocturnal activity ceased around 06h00.

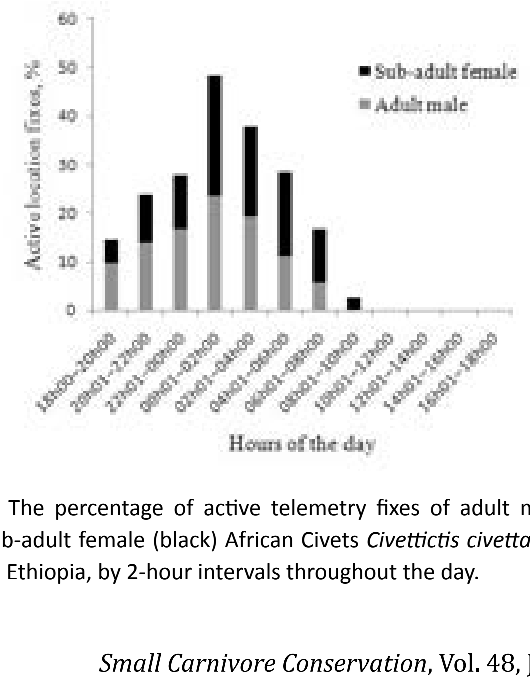

Fig. 3. The percentage of active telemetry fixes of adult male (grey) and sub-adult female (black) African Civets *Civettictis civetta* in Wondo Genet, Ethiopia, by 2-hour intervals throughout the day.

Fig. 4. Denning site for the sub-adult female African Civet *Civettictis civetta* within a thorny bush, Wondo Genet, Ethiopia.

Den sites

The male used two den sites before its disappearance from the study area; both were in natural forest. The distance between the two sites was 230 m, and the dens were entered through cracks of rocks. The pattern of use of the two dens was not clear. There were also two den sites for the sub-adult female, in dense bushy vegetation near human settlement (Fig. 4). The first den was abandoned in April 2007, when the female moved to a second one about 250 m from the first. Both individuals mostly visited their civetry during the morning, around 05h00–06h00.

Discussion

A wide range of home-range sizes has been recorded for other ground-dwelling civet species, such as Malay Civet *Viverra tangalunga*, a South-east Asian forest species (Macdonald & Wise 1979, Colón 2002, Jennings *et al*. 2006, 2010), and a difference in habitat productivity and food availability was suggested as the probable reason (Jennings *et al*. 2006). The home ranges of the sub-adult female and the adult male African Civets in this study were considerably smaller than that of a sub-adult male in the Bale Mountains, Ethiopia (Admasu *et al*. 2004). Anthropogenic food resources may reduce home-range size and movements of carnivores (Quinn & Whisson 2005), and human-modified habitats may also have enhanced abundance of prey such as rodents and insects. Admasu *et al*. (2004) suggested that the small core area of the Civet in their study was probably influenced by the food resources in the Bale Mountains National Park headquarters and the adjacent town. Thus, the diversity of habitat types in Wondo Genet, including extensive overlap with people, may have provided rich food resources for these Civets, allowing their small home ranges there.

The sub-adult female used its range in a more intensive way than the adult male. Diet analysis in the same study area revealed that the younger Civet preferred to feed on protein-rich food sources than on plant foods; the male fed mostly on plant sources (AB own data).

The present study showed that two African Civets in synanthropic Wondo Genet were active during the night from about 19h00 to 06h00. Other species of civets also show nocturnal activity (Macdonald & Wise 1979, Rabinowitz 1991, Grassman 1998). The later emergence of the sub-adult female than the adult male (Fig. 3) near the human settlement might be caused by the presence of humans in the area during dusk. Cattle-grazing was observed in the study area until 19h30 on some days, and the collared Civets left their den just after the cattle and people had left the area.

Acknowledgements

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Presence of a small population of a polecat-like mustelid in north Algeria, potentially the wild progenitor of Domestic Ferret *Mustela furo*

Mourad AHMIM

Abstract

Wild-living animals allied to Western Polecat *Mustela putorius* and its domesticated relative, Domestic Ferret *M. furo* do not seem to have been previously documented in Algeria. A small population was discovered in March 2013 in Maamoura, which local people report has been present for at least 60 years. Further investigations, including DNA sequencing, are essential to determine (1) whether these animals are an autochthonous wild population or an introduction, and (2) the extent, if any, to which they are descended from Domestic Ferrets.

Keywords: DNA sequencing, *Mustela putorius*, wild strain

Présence d'une petite colonie de mustélidés de « type putois » au nord de l'Algérie, potentiellement la souche sauvage du Furet domestique *Mustela furo*

Résumé

Des animaux vivant en milieu sauvage apparentés au Putois d'Europe *Mustela putorius* et à sa forme domestiquée, le Furet domestique *M. furo* ne semblent pas avoir été documentés auparavant en Algérie. Une petite colonie a été découverte en mars 2013 à Maamoura, colonie qui, selon les habitants locaux, existerait depuis au moins 60 ans. Des recherches supplémentaires, incluant un séquençage ADN, seront essentielles pour déterminer (1) si ces animaux constituent une population sauvage autochtone ou résultent d'une introduction, et (2) dans quelle mesure, si relevant, leurs ancêtres comprenaient des Furets domestiques.

Mots clés: *Mustela putorius*, séquençage ADN, souche sauvage

Domestic Ferret *Mustela furo* is a close relative of Western Polecat *Mustela putorius*, but neither its geographical nor its taxonomic origins are well documented. Gippoliti (2011) adduced evidence to suggest that Domestic Ferrets may be derived from a wild animal of North Africa. The wild-living North African animals resembling Western Polecats are treated inconsistently in various taxonomic sources, usually as within Western Polecat. If they comprise an autochthonous wild taxon (rather than the descendents of Domestic Ferrets and/or of Polecats introduced from Europe), then they seem to lack a scientific name: *furo* can be used only for domestic animals and their progeny (Gentry *et al*. 2006), and no other name associated with *M. putorius* has a type locality in Africa. In a review of Algerian mammal records, Kowalski & Rzebik-Kowalska (1991) considered that there were no reliable records of wild polecat-like animals from Algeria. Nor were any traced by Gippoliti (2011) or Griffiths & Cuzin (in press). None of these authors gave any evidence for such animals outside Morocco. I recently learnt of a small population of a wild-living polecat-like animal, in north-central Algeria which is morphologically close to or within Western Polecat. Based on the conclusions of Gippoliti (2011) about Moroccan animals, and on their location as wild-living animals in North Africa, these Algerian animals may also potentially be among the wild progenitors of Domestic Ferret. However, they could instead potentially be the descendents of Domestic Ferrets and/or Western Polecats imported from Europe in the past, or a population descended from both autochthonous wild animals and introductions.

On 10 March 2013, a live specimen of a polecat-like animal (Fig. 1) was given to me by a friend, who told me that there is a population of these animals in the region of Maamoura. This is a commune in the southeast of Sour-el-Ghozlane, Bouïra province, Algeria (35°57′30″N, 3°37′13″E; Fig. 2). I visited the locality and asked residents about these animals. They told me that they live in a forest and maquis habitat near the town, and have been present for at least 60 years. The population size was said to be about 30 animals. Some are now in captivity. The main threat to the colony at Maamoura seems to be the capture of the animals for hunting European Rabbits *Oryctolagus cuniculatus*, as was noted by Cabrera (1932) to occur in Morocco.

I also received reports of sale of these animals in some markets in the west of Algeria. As far as I know, captive ferrets kept in Algeria are all animals caught in North Africa or their progeny. I have heard of no imports from outside North Africa, and I have never seen or heard of an animal with a white pelt (such as comprise the majority of Domestic Ferrets in Europe). Distinguishing between Western Polecats and Domestic Ferrets is extremely challenging, in part because of considerable interbreeding between them (Davison *et al*. 1999). Moreover, the wild-living animals of Morocco remain inconsistently treated (Gippoliti 2011) and are not well diagnosed morphologically. Therefore, identification of these animals from Maamoura will require considerable further investigation, including consideration of how similar they are to wild-living Moroccan animals. Detailed morphological and DNA analysis would be required in order to determine the Maamoura population's likely origin and thus taxonomic affinity. Such analysis is urgent, given the conclusion of Gippoliti (2011) that the hypothesised North African wild taxon ancestral to Domestic Ferret is highly threatened, if

Fig. 1. Captive polecat-like animal, *Mustela* cf. *putorius furo*, from Maamoura, Bouïra province, Algeria, 16 March 2013. Four views of the same individual.

Fig. 2. Location of Maamoura, Algeria, which holds a small population of a wild polecat-like animal, *Mustela* cf. *putorius furo*.

it persists at all. The population at Maamoura seems to be small (this is yet to be confirmed) and conservation work is likely to be essential, if the population is found to be of conservation interest. This latter would be so if they are a pure-bred wild population. It would also be likely if they have some Domestic Ferrets in their ancestry, but still retain genetic material from their wild ancestor not present in modern Domestic Ferrets.

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First record of Johnston’s Genet *Genetta johnstoni* in Senegal

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Abstract

Johnston’s Genet *Genetta johnstoni* is an elusive small carnivore endemic to the Upper Guinean forests. The species was recently assessed as Vulnerable by *The IUCN Red List of Threatened Species*. Its known occurrence is mostly restricted to the rainforests of Ghana, Côte d’Ivoire, Liberia, Sierra Leone and Guinea. We here present the first sighting of the species in Senegal, through a camera-trap video recorded on April 2011 in Dindefelo Natural Reserve, south-eastern Senegal, about 260 km north of the species’s westernmost previous known occurrence. Our observation adds further support to the hypothesis that Johnston’s Genet may inhabit certain forest–savannah mosaics.

Keywords: Dindefelo, forest–savannah mosaics, Kedougou, Upper Guinean forests, Viverridae

Première observation de la Genette de Johnston *Genetta johnstoni* au Sénégal

Résumé

La Genette de Johnston *Genetta johnstoni* est un petit carnivore discret, endémique du Bloc forestier de Haute Guinée. Le statut de l’espèce a été récemment évalué « Vulnérable » par la *Liste Rouge des Espèces Menacées de l’UICN*. Son aire de répartition connue est principalement restreinte aux forêts tropicales humides du Ghana, de la Côte d’Ivoire, du Libéria, de la Sierra Leone et de la Guinée. Nous présentons ici la première observation de l’espèce au Sénégal, grâce à une capture vidéo enregistrée en Avril 2011 dans la Réserve Naturelle de Dindéfélo, au sud-est du Sénégal, à environ 260 km au nord de la plus proche occurrence préalablement connue de l’espèce. Cette observation renforce l’hypothèse que la Genette de Johnston peut occuper un habitat de type « mosaïque forêts–savanes ».

Mots clés: Dindéfélo, forêts de Haute Guinée, Kédougou, mosaïque forêts–savanes, Viverridae

Johnston’s Genet *Genetta johnstoni* Pocock, 1908 is a poorly known small carnivore from West Africa, with a known distribution encompassing the Upper Guinean rainforests, including five countries: Ghana, Côte d’Ivoire, Liberia, Sierra Leone and Guinea (Dunham & Gaubert 2013; Fig. 1). Gaubert *et al*. (2002) identified a total of 24 specimens in museum collections worldwide. Johnston’s Genet was thought to be restricted to lowland moist forests west of the so-called Dahomey Gap, also inhabiting swamp and riverine forests, but its geographical range and ecological niche have been proposed to show a wider spectrum, possibly including moist woodlands and savannahs from Guinea (Gaubert *et al*. 2002, Papeş & Gaubert 2007). The species is classified as Vulnerable on *The IUCN Red List of Threatened Species*, based on its inferred rate of population decrease (based on forest loss within its range) and the plausible impact of bushmeat hunting (Dunham & Gaubert 2008).

At 23h15 on 24 April 2011, we video-recorded (15 seconds) a slender genet drinking at a small waterhole in Dindefelo (12°24′N, 12°18′W, altitude 350 m, Google Earth digital elevation model), Kedougou region, south-eastern Senegal. In this location, close to the Guinean border, the Spanish branch of the Jane Goodall Institute is implementing a research and conservation project with the ultimate goal of proposing a 15,000 ha community-managed natural reserve. As part of this project, an inventory of mammals is being carried out, through both enquiries of villagers and camera-trapping. Hence, a set of three camera-traps (Scoutguard SG560) have been operating in the field on a non-systematic basis.

The video (which can be viewed at http://www.youtube.com/watch?v=sfN6SUCG-L0&feature=plcp) was analysed in detail, and the individual was positively identified as a Johnston’s Genet according to the criteria of Gaubert *et al*. (2008).

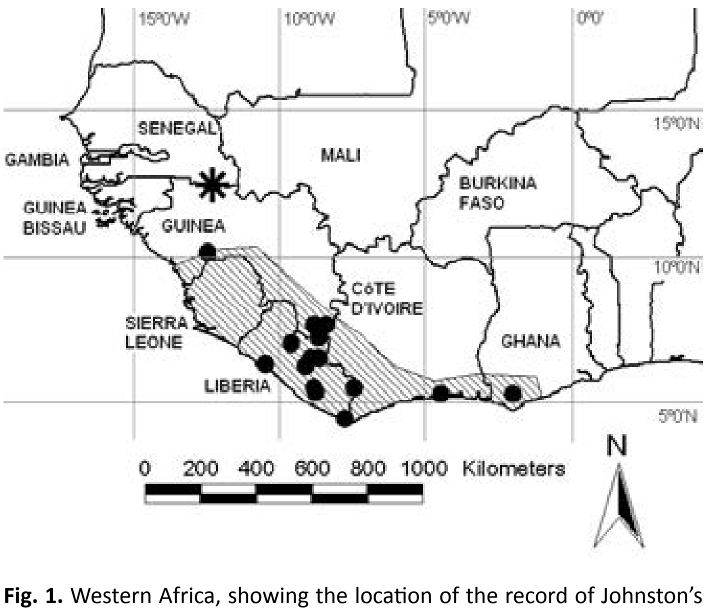

Fig. 1. Western Africa, showing the location of the record of Johnston’s Genet *Genetta johnstoni* here reported (asterisk), records of the species compiled by Gaubert *et al*. (2002) (black dots), and generalised range as delineated by Dunham & Gaubert (2008).

Fig. 2. Johnston's Genet *Genetta johnstoni*, Dindefelo Natural Reserve, south-eastern Senegal, on 24 April 2011.

It was a lightly-built genet, with elongated body and face, relatively large eyes, and a long tail (Fig. 2). The estimated head-body length, deduced from side view, was similar to that of the tail. Some well-defined characteristics included a mid-dorsal dark stripe contrasting with the brownish dorsal spots, the absence of well-defined nuchal stripes, the densely-spotted coat and coalescence of dorsal spots at the rump. The tail had eight pale rings, their width being less than 20% of that of the dark rings (middle of the tail). The tip of the tail, though ill-defined, was pale but mixed with dark hairs. The hindlimbs and forelimbs were darker than ground coloration.

These features are, overall, consistent with the distinguishing characteristics of Johnston's Genet, more than with any other West African genet. Following Gaubert *et al*. (2005, 2008), other genet species that might co-occur with Johnston's Genet can be distinguished from the latter by the following features:

- Common or Small-spotted Genet *G. genetta*: presence of a mid-dorsal crest, equal width of pale and dark tail-rings, and lower density of dorsal spots;
- Hausa Genet *G. thierryi*: rufous-brown dorsal line (often split into two longitudinal stripes by a brighter median stripe), equal width of pale and dark rings of the tail, and lower density of dorsal spots;
- King Genet *G. poensis*: heavier proportions, larger head, and fewer pale rings on the tail (4–6);
- Bourlon's Genet *G. bourloni*: shorter tail relative to head-body length, well-spotted forefeet, fewer pale rings on the tail (5–7) and almost completely dark distal half of the tail;
- Pardine Genet *G. pardina*: heavier body, tail shorter than head-body length, fully dark tip of the tail, fewer pale rings on the tail (6–7), and absence of coalescence in the first row of dorsal spots.

The checklist of small carnivores recorded in the study area is still expanding. So far, the other confirmed species of genets are Common Genet and Hausa Genet (LP & NRDA own data). In the Niokolo–Koba National Park, the south-eastern border of which lies about 50 km away from Dindefelo, Common Genet, Pardine Genet and Hausa Genet have all been recorded (Sillero-Zubiri & Marino 1997).

Fig. 3. Semi-deciduous forest patch where the Johnston's Genet *Genetta johnstoni* was recorded in Dindefelo Natural Reserve, Senegal. (Photo: N. Ruiz de Azua).

This first observation of a Johnston's Genet in Senegal is a remarkable record, not only because it may extend the known range of this rare, little-known species about 260 km north from its north-westernmost previously known occurrence (Kolenté Plateau, Guinea; Gaubert *et al*. 2002; Fig. 1), but also because of the vegetation and ecological features of the study area. Dindefelo Natural Reserve is located at the northern edge of the Guinean forest–savannah ecoregion (Burgess *et al*. 2004), characterised by a mosaic of semi-deciduous and riverine gallery forest patches and wooded savannahs (Fig. 3). Although most previously accepted observations of Johnston's Genet suggested that rainforest is the species's typical habitat, the reassessment of Gaubert *et al*. (2002) also presented a record from moist woodland in Guinea. Besides, Papeş & Gaubert (2007) developed geographically explicit distribution models predicting suitability of the deciduous forests in the Fouta Djallon highlands, a massif of which the northern slope lies towards the Senegal border in Dindefelo area. Thus, this observation at Dindefelo supports the view of a wider distribution and ecological niche for this threatened species.

Acknowledgements

The Dindefelo field team included Diba Diallo and Dauda Diallo. The project 'Biological inventories in the Dindefelo Natural Reserve' was funded by Wula Naafa (USAID) and Fundación Biodiversidad (Spanish Ministry for the Environment). Javier Calzada, Miguel Delibes and Wim Wendelen provided expert advice. The comments by Mark Taylor, Vladimir Dinets and Emmanuel Do Linh San improved the draft.

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First report of a chinchilla phenotype in Viverridae (Carnivora)

Philippe GAUBERT[1] and Sylvain DUFOUR[2]

Abstract

We report on the first case of a chinchilla phenotype in Viverridae (Carnivora), on the basis of a skin of Hausa Genet *Genetta thierryi* originating from Réserve de Faune de Kankan, Republic of Guinea. The specimen exhibits pale rufous brown spots likely to have been caused by eumelanin degradation, and uniform pale creamy orange background coloration probably due to lower concentration of phaeomelanin.

Keywords: coat colour, genet, *Genetta thierryi*, Republic of Guinea, West Africa

Première mention d'un phénotype *chinchilla* chez les Viverridae

Résumé

Nous mentionnons le premier cas de phénotype chinchilla chez les Viverridae (Carnivora), sur la base d'une peau de Genette de Villiers *Genetta thierryi* provenant de la Réserve de Faune de Kankan, en République de Guinée. Le spécimen montre des taches marron-roux pâle vraisemblablement causées par une dégradation de l'eumélanine, et une couleur de pelage orange crème pâle probablement diagnostique d'une concentration plus faible de phéomélanine.

Mots clés: Afrique de l'Ouest, couleur du pelage, genet, *Genetta thierryi*, République de Guinée

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In mammals, the colour of hairs, skin and eyes stems from the biosynthesis of a range of melanin pigments occurring in melanocytes. Such pigments arise from a common metabolic pathway where a series of enzymes is involved in different oxidation steps catalysed by tyrosinase. Thus, mutations that affect melanin biosynthesis have a global impact on the organism, including on retinal pigments. Probably the best-known mutation of this type is albino, where the loss of the oxidative function of tyrosinase results in a white phenotype with red eyes. Melanocytes synthesise two types of melanins, namely eumelanin (brown/black) and phaeomelanin (red/yellow), both requiring the action of tyrosinase (Hearing & Tsukamoto 1991, Barsh 2001, Ito & Wakamatsu 2003). Melanocytes from hair follicles may switch between eumelanin and phaeomelanin (or both at the same time) synthesis, a mechanism responsible for the great coat colour polymorphism observed in natural populations of mammals (Furumura *et al*. 1996, Barsh 2001) and which is likely to be involved in adaptive cryptic colorations (Singaravelan *et al*. 2010).

The large extent of gradual variation in coat pattern and colour in carnivores (order Carnivora) is well documented, both in domestic stocks (Kaelin & Barsh 2013) and wild populations (Little 1958, Robinson 1976). The most common of the 'aberrant', genetically-determined coat colour mutants in wild carnivores is melanism (prevalence of black pigmentation), almost reaching local fixation in Jaguar *Panthera onca* (Eizirik *et al*. 2003). Other coat-colour mutants found within carnivores are albinism (absence of melanin) and erythrism (prevalence of red pigmentation) (Little 1958, Veron *et al*. 2004). Contrary to most of the gradual coat colour variation observed in 'standard' phenotypes, the adaptive nature of those three classes of phenotypic mutants is still uncertain in carnivores (Robinson 1976, Caro 2005, Hedrick 2009). Cats (Felidae) are probably the carnivores that show the widest clinal variation in coat pattern and colour (Robinson 1976), including melanistic specimens observed in 11 out of the 37 species as well as chinchilla mutants such as 'white' Lions *Panthera leo*, Tigers *P. tigris* and Ocelots *Leopardus pardalis* (Robinson 1976, McBride & Giordano 2010). Recent studies have shown the complexity of aberrant coat colour acquisition in cats, suggesting at least five independent mutational pathways encoding melanism (Eizirik *et al*. 2003, Schneider *et al*. 2012).

Civets and allies (Viverridae) exhibit a wide range of coat pattern and colour variation, also including mutants such as albino, melanistic and erythristic phenotypes (Webb 1947, Sharma 2004, Veron *et al*. 2004, Eaton *et al*. 2010, Gaubert & Mézan-Muxart 2010, Delibes *et al*. 2013). In the genets *Genetta*, the wide variation observed in coat pattern and colour has been responsible for some long-standing taxonomic confusions (Gaubert 2003, 2013, Gaubert *et al*. 2005, 2008). Aberrant phenotypes do also occur at various (but low) frequencies, including albino individuals in Common Genets *Genetta genetta* from Europe (Delibes *et al*. 2013) and melanistic specimens of Miombo Genet *G. angolensis*, Servaline Genet *G. servalina*, Rusty-spotted Genet *G. maculata* (Africa) and *G. genetta* (Europe) (Webb 1947, Gaubert & Mézan-Muxart 2010, Barrull & Mate 2012). We here add to the list of phenotypic aberrations within the Viverridae by reporting the first case of a chinchilla mutant, on the basis of a skin of Hausa Genet *G. thierryi* collected in the Réserve de Faune de Kankan, Republic of Guinea (West Africa).

Four sun-dried skins of genets, including an aberrant 'creamy-rufous' specimen, were collected from Nalankoni (10°05′N, 8°35′W), in the Réserve de Faune de Kankan, Republic of Guinea, between 26 March and 6 June 2009, during a participatory community management conservation project conducted by SYLVATROP. The Réserve de Faune de Kankan is located east in the Republic of Guinea, at the border with Côte d'Ivoire, in the Guinean savanna belt. Mean annual rainfall, temperature and relative humidity reach 1,673 mm, 26 °C and

66%, respectively. The vegetation is a mix of periodically flooded grassy plain (consisting mainly of grasses on waterlogged soils), wooded savannas with scattered trees and shrubs, and forest galleries along permanent streams. The exact habitat(s) from which the genets were taken is/are unknown.

We used the computer-assisted identification key of Gaubert *et al*. (2008) and PCR-amplified short fragments of cytochrome *b* (DNA extraction protocol from Gaubert & Zenatello [2009]; specific primers from Gaubert *et al*. [2011]; data not shown) to reach species identification of the four skins collected. The specimens were deposited at the mammals and birds (Mammifères et Oiseaux) collections, Muséum National d'Histoire Naturelle, Paris (MNHN), France.

Two skins were identified as West African Large-spotted Genets *G. pardina* (MNHN 2010-1260 and -1263), while the two others were Hausa Genets *G. thierryi* (MNHN 2010-1261 and -1262), including the aberrant 'creamy-rufous' specimen (MNHN 2010-1261; Fig. 1). The latter exhibits pale rufous brown spots and uniform pale creamy orange background coloration. We could not observe any black hairs, whereas a fair proportion of white hairs occurs over the entire skin (i.e. spots and background). The other specimen of *G. thierryi* (MNHN 2010-1262) collected at the same period and coming from the same general locality has dark brown spots and brown (back) to yellow (belly) ash-grey ground coloration. Such a colour pattern is included in the phenotypic range of the species (Gaubert & Dunham 2013a). The two individuals of *G. pardina* collected from the same area exhibited standard phenotypic characters of West African Large-spotted Genets from the Guinean savannah (Gaubert 2003, Gaubert & Dunham 2013b).

Loss-of-function in genes involved in the synthesis of eumelanin can result in black coat markings turning to red. Such alterations of eumelanin synthesis have variable effects on coat colour depending on whether or not phaeomelanin is synthesised (Barsh 2001). The aberrant specimen of *G. thierryi* that we describe here refers clearly to a chinchilla mutant, a phenotype already observed in carnivores such as white Lions and white Tigers. In those cats, the chinchilla mutants show a reduced amount of all the melanin pigments, with more viewable effects on the yellow (phaeomelanin) than on the brown or black (eumelanin) pigmented areas (Robinson 1976). In white Lions, spots turn pale sepia brown (degradation of eumelanin) while the background coat colour becomes light fawn (low concentration of phaeomelanin) (Robinson & Vos 1982). Similarly, in white Tigers phaeomelanin is expressed as pale beige and eumelanin is degraded to sepia brown (Robinson & Vos 1982), in such a way that markings and spots are still visible but appear less clearly. We can also relate the chinchilla phenotype observed in the Hausa Genet to the "amber light silver mackerel tabby" Norwegian Forest Cat (a breed of domestic cat *Felis catus*) represented in Peterschmitt *et al*. (2009: 549: Fig. 2e): the individual has a light pinkish-beige colour with a toned down tabby pattern. It is unfortunate that we could not observe the genet specimen alive to reinforce our diagnosis, because chinchilla phenotypes should have bluish or whitish irides with reddish pupils (Robinson 1976).

The chinchilla phenotype is linked to the specific allele C^{ch} of the *full color* (Robinson 1976) or *albino/tyrosinase* (Lamoreux *et al*. 2001) locus *C*. The *chinchilla* allele encodes a partly functional tyrosinase, with the consequence of drastically restraining the synthesis of phaeomelanin and degrading the

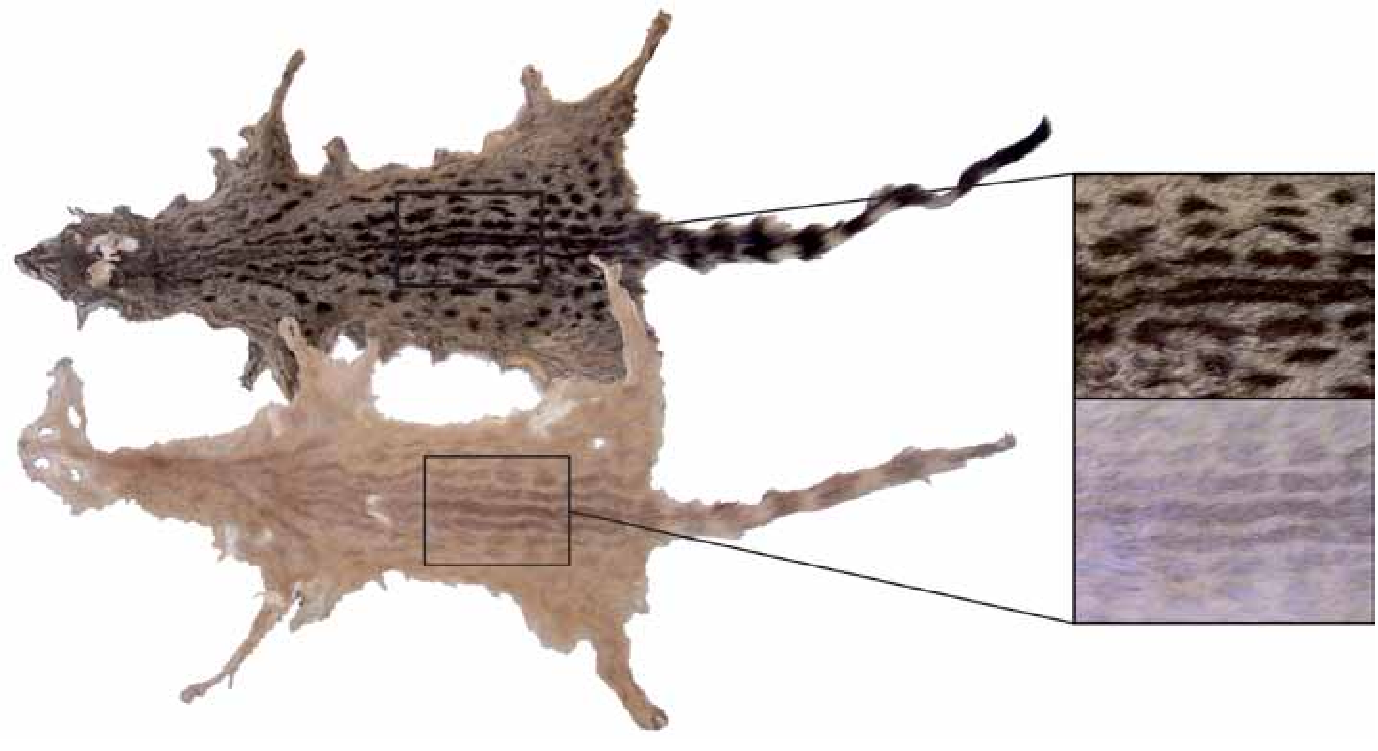

Fig. 1. Coat colour variation in Hausa Genets *Genetta thierryi* from Nalankoni, Réserve de Faune de Kankan, Republic of Guinea. Top: standard phenotype (MNHN 2010-1262). Bottom: chinchilla mutant (MNHN 2010-1261). Boxes on the right correspond to the zoomed dorsal areas of the coats.

eumelanin pigment (Robinson & Vos 1982, Ito & Wakamatsu 2011). Due to the preferential dilution of phaeomelanin observed in C^{ch} mutants, the characteristic chinchilla phenotype has a banding pattern of eumelanin alternated with cream-coloured phaeomelanin, a pattern similar to that observed in the specimen MNHN 2010-1261. The fact that the latter does not exhibit a pure white background colour (meaning that phaeomelanin is still synthesised) does not go against its attribution to the chinchilla phenotype, since several levels of background paleness have been described among carnivore C^{ch} mutants (Little 1958, Robinson & Vos 1982, Peterschmitt *et al*. 2009), even within the same species (Robinson 1976).

It is exceptional to find such an aberrant coat colour pattern in Hausa Genet, since it is to our knowledge the first time a chinchilla mutant is reported among the Viverridae. Given the scant data associated with the specimen collected, we cannot assess the potential adaptive or deleterious value of its aberrant phenotype. However, the individual was most likely a full-grown adult (head and body length = 51 cm; see Gaubert & Dunham 2013a), that had survived in the wild despite its pale coat colour.

The Viverridae remains a fascinating group to study coat pattern and colour variation, given its wide range of clinal variability and the existence of aberrant phenotypes such as melanistic, albino, erythristic and – as described here for the first time – chinchilla.

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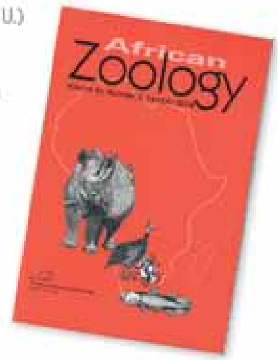

Common Cusimanse *Crossarchus obscurus* in Ghana and Flat-headed Cusimanse *C. platycephalus* in Nigeria: a tentative comparison between habitat parameters affecting their distribution

Francesco M. ANGELICI[1] and Massimiliano DI VITTORIO[2]

Abstract

Common Cusimanse *Crossarchus obscurus* and Flat-headed Cusimanse *C. platycephalus* are two taxa (species or subspecies) found in West and Central Africa. Their ranges are close to each other, probably as a result of allopatric speciation. This preliminary work compares some environmental parameters relative to the locations where they were both trapped by local hunters (respectively, in Ghana and Nigeria), to compare their habitat use. *Crossarchus platycephalus* appears more tolerant of mosaic or partially-degraded environments than *C. obscurus*, although overall the two taxa show rather homogeneous patterns.

Keywords: ecology, geographic range, Ghana, Nigeria

Le Crossarque commun *Crossarchus obscurus* au Ghana et le Crossarque à tête plate *C. platycephalus* au Nigeria: une comparaison préliminaire des paramètres environnementaux relatifs à leur répartition

Résumé

Le Crossarque commun *Crossarchus obscurus* et le Crossarque à tête plate *C. platycephalus* sont deux taxons (espèces ou deux sous-espèces d'une même espèce) présentes en Afrique occidentale et centrale. Leurs aires de répartition sont proches l'une de l'autre, ce qui reflète probablement le résultat d'une spéciation allopatrique. Dans ce travail préliminaire, certains paramètres environnementaux ont été comparés sur la base des localisations où les deux taxons ont été capturés par les chasseurs locaux, respectivement (respectivement, au Ghana et au Nigeria), pour mettre en évidence les différences et/ou les similitudes dans leur utilisation de l'habitat. A partir de ces premiers résultats, les principales données qui émergent sont la probablement plus grande tolérance de *C. platycephalus* à des environnements fragmentés ou partiellement dégradés en comparaison avec *C. obscurus*, même si globalement les deux taxons présentent des préférences écologiques relativement homogènes.

Mots clés: écologie, Ghana, Nigeria, répartition géographique

Introduction

The study of aphanic or sibling species (*sensu* Mayr 1970, Dobzhansky 1972, Steyskal 1972) is of particular interest because, both in allopatry or sympatry, it can provide information on their eventual ecological divergence (Ridley 1993). Scientists traditionally considered pairs or groups of species as sibling species based upon morphology, biogeography and anatomy, but recent advances in DNA analyses and molecular phylogeny have allow more confident determination whether two or more species are in reality sibling species (Puillandre *et al*. 2011). In mammals, various examples of sibling species have been described (e.g. Dobigny *et al*. 2003).

In the genus *Crossarchus* (family Herpestidae), endemic to the Afrotropical (or Ethiopian) region, four species are generally now recognised: Common Cusimanse *Crossarchus obscurus* F. G. Cuvier, 1825; Flat-headed Cusimanse *C. platycephalus* Goldman, 1984; Alexander's Cusimanse *C. alexandri* (Thomas & Wroughton, 1907); and Ansorge's Cusimanse *C. ansorgei* (Thomas, 1910). All are morphologically very similar (see Hunter & Barrett 2011). Common Cusimanse (Fig. 1a–b) is widespread in West Africa from eastern Guinea to the Dahomey Gap; its eastern range extends just east of the River Volta (Dunham *et al*. 2008). Flat-headed Cusimanse (Fig. 1c–d) occurs from Nigeria to north Gabon and Congo (Goldman & Hoffmann 2008, Hunter & Barrett 2011), and in southern Benin (Djagoun & Gaubert 2009, Djagoun *et al*. 2009). The two are often considered conspecific, under the name *C. obscurus* (e.g. Wozencraft 2005). They differ in some dimensions and shape of skull bones, but external morphological differences are almost insignificant and hardly detectable (cf. Goldman 2013, Goldman & Dunham 2013) (Fig. 1). The two seem to have allopatric ranges, although we cannot exclude their co-occurrence in the contact and/or border areas (Fig. 2). Of the other two species, *C. alexandri* is endemic to central Africa and *C. ansorgei* is widespread in north Angola and south-east Congo (Wozencraft 2005); *C. alexandri* is believed to overlap slightly with *C. platycephalus*, but *C. ansorgei* is apparently geographically separate, although not by much. Neither shows any overlap with *C. obscurus* (Gilchrist *et al*. 2009).

Common Cusimanse has been recorded in dense undergrowth of rainforest, but also in farm bush, logged forest, plantations, humid savannah areas of savannah gallery forests, and even in dry open grassland and thicket. The known range extends from sea level to about 1,500 m a.s.l. (Gilchrist *et al*. 2009, Goldman & Dunham 2013). Flat-headed Cusimanse was recorded or trapped by local hunters in bush, abandoned farmland, marshy areas, primary and secondary rainforests, and

Fig. 1. Left: Common Cusimanse *Crossarchus obscurus*, 15 June 2008, near Bekwai (Ashanti Region, Ghana); right: Flat-headed Cusimanse *Crossarchus platycephalus*, 28 August 2009, surroundings of Port Harcourt airport (Rivers State, Nigeria).

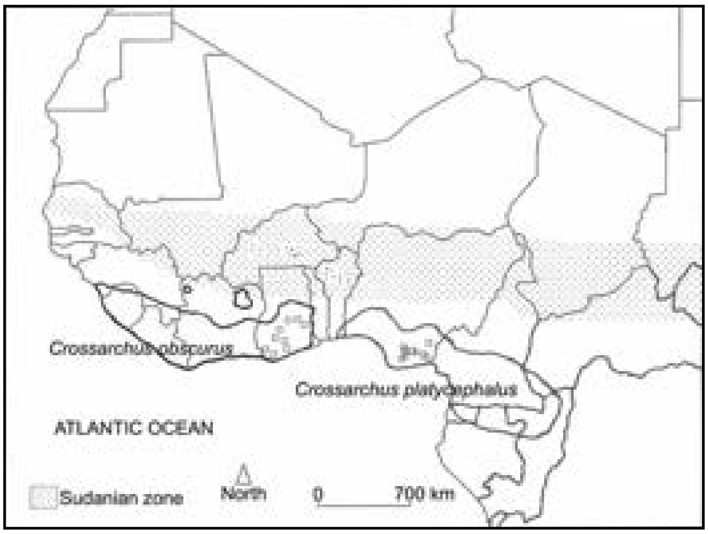

Fig. 2. World ranges of Common Cusimanse *Crossarchus obscurus* (western) and Flat-headed Cusimanse *C. platycephalus* (eastern). The squares indicate trapping localities of animals used in the present investigation.

even close to upper mangrove and in largely deforested lowland zones, overall from sea level up to 1,600 m a.s.l. (Powell 1997, Angelici *et al*. 1999a, 1999b, 1999c, Goldman & Hoffmann 2008, Gilchrist *et al*. 2009, Goldman 2013).

This study compares, on a preliminary basis, components of the habitats where Common Cusimanse and Flat-headed Cusimanse were captured, to highlight differences or similarities in their selected environments. Knowledge of species distribution patterns and identification of factors influencing them are crucial to species conservation (Channel & Lomolino 2000, Whitfield 2005). Both species are listed Least Concern (LC) in *The IUCN Red List of Threatened Species*, i.e. they are considered not to be at short- to mid-term risk of extinction, even if the population trend is unknown for both (Dunham *et al*. 2008, Goldman & Hoffmann 2008).

Study area and methods

Study area

Animals were studied in Ghana for *C. obscurus* in 2005–2012, and in Nigeria for *C. platycephalus* in 1997–2011 (Fig. 2). No animal was captured or killed expressly for this research: the individuals were sold on the roads as bushmeat (see Angelici *et al*. 1999c). Like many other species of carnivores and of mammals in general, local hunters trapped them in locally-built traps, almost always consisting of metal loop snares, made of brake or clutch wire for bicycles or motorcycles.

We used only data for those specimens where the vendor who was also the captor, showed us the exact location of capture. We visited all places of capture, noting the environmental variables (Table 1) and scoring them as (1) semi-natural or (2) natural habitat.

Statistical analysis
We analysed the correlation between variables through the use of *r* Pearson statistic (Cox & Hinkley 1974, Edwards 1976). We applied the *t* statistic to test the differences between the two species, using the elevation a.s.l. and habitat composition as variables. We used Generalized Linear Models (GzLMs) to model the species habitat preferences (see Agresti 1996, Hosmer & Lemeshow 2000, Whittingham *et al*. 2006) using elevation a.s.l., land use, and the distribution of other mammals and other species of carnivores as predictors. The trapping data (occurrences) were used as the independent variable and normal logit design was used.

Results

Cusimanse records are shown in Table 1. For both *C. obscurus* ($r = 0.83$, $P = 0.004$) and *C. platycephalus* ($r = 0.91$, $P < 0.001$), we found a significant correlation between the total number of trapped individuals and the total number of trapped carnivores. The *t* test results show significant differences between the two species in elevation ($t = -2{,}60$, $df = 36$, $P = 0.013$) and habitat composition ($t = 603.88$, $df = 36$, $P < 0{,}001$). *Crossarchus platycephalus* appears linked to semi-natural environments, i.e. at least partly degraded (68.2% of records), while *C. obscurus* tends to use natural environments (61.11% of

Table 1. Locality and habitat data for the specimens examined of Flat-headed Cusimanse *Crossarchus platycephalus* and of Common Cusimanse *C. obscurus*.

Locality	Habitat code[1]	Habitat score	Altitude (m)	A[2]	B[3]	C[4]
Flat-headed Cusimanse *Crossarchus platycephalus* (Nigeria)						
Surroundings of Port Harcourt airport (4°51′05″N, 7°00′59″E)	2 for agric	1	27	5	6	16
Abarikpo (5°03′40″N, 6°39′49″E)	Abb agr bush	1	220	2	2	8
Otari (4°51′18″N, 6°50′13″E)	1 for, marsh degr	2	178	1	2	4
Tombia forest (4°47′19″N, 6°53′35″E)	2 for, marsh, bush,farm	2	355	1	2	5
Orashi river (4°44′18″N, 6°38′46″E)	1 for, marsh degr agrabband	2	270	3	5	7
Omoku (Upper Orashi Forest reserve) (5°21′06″N, 6°39′07″E)	1 for low degr	2	17	1	1	3
Billebokiri (4°51′29″N, 6°55′15″E)	Riv mangr-agr and 2 for	1	5	4	6	9
Abia surroundings (5°06′53″N, 7°22′01″E)	Frag bush agr	1	400	1	2	4
Akampka (5°18′07″N, 8°21′29″E)	Mixfor	2	160	1	2	6
4 km east of Ikot-Ekpene (5°10′50″N, 7°42′43″E)	Frag bush agr	1	155	3	5	8
Common Cusimanse *Crossarchus obscurus* (Ghana)						
Surroundings of Obuasi (6°11′29″N, 1°39′43″W)	frag bush agr, dec for	1	101	2	4	6
5 km west of Bekwai (6°26′48″N, 1°34′52″W)	Guinea Forest	2	172	2	5	7
Oda (5°54′30″N, 0°59′22″W)	Everfor	2	127	1	2	4
Atwidie (6°35′22″N, 1°04′41″W)	semdecfor	2	225	3	5	6
12 km north of Kikam (4°55′34″N, 2°19′18″W)	2 for and 1 for	2	71	1	2	4
5 km east of Gyema (5°25′21″N, 2°41′22″W)	1 for degr areas	2	54	3	3	5
Begoro (6°23′02″N, 0°22′38″W)	Preserv for	2	447	1	2	3
Dunkwa (5°21′10″N, 1°40′33″W)	2 for frag farm wat	1	118	4	7	9
Nkawkaw (6°33′09″N, 0°46′01″W)	Semdecfor farm wat	1	271	1	3	7

[1]**Habitat codes**. **2 for agric:** secondary rainforest, fragmented with agricultural areas; **Abb agr bush:** abandoned agricultural area, with fallow bush, oil palms and colonising arboreal species; **1 for, marsh degr:** primary rainforest in a marshy area, degraded through human activities; **2 for, marsh, bush, farm:** mature secondary forest situated close to a brackish marsh, near secondary rainforest, bush, secondary swamp forest, lower mangrove and farmland; **1 for, marsh degr agrabband:** primary rainforest partially degraded to secondary rainforest, near secondary rainforest, bush, farmland, water bodies and some formations of upper mangrove; **1 for low degr:** primary rainforest with large trees, but moderate degradation through human activity; **Riv mangr-agrand 2 for:** riverine area with mangroves, cassava, banana and oil palm fields, and patches of secondary forest; **Frag bush agr:** fragmented altered bush with farmland; **Mixfor:** mixed primary and secondary rainforest; **Frag bush agr:** bush, fragmented farmland, degraded forest; **Frag bush agr, dec for:** bush fragmented with some farmland (palm oil, cocoa), bordering semi-deciduous forest; **Guinea forest:** Guinea (moist semi-deciduous) forest; **Everfor:** evergreen forest near semi-deciduous forest; **Semdecfor mois:** semi-deciduous forest; **2 for and 1 for:** secondary rainforest with fragment of primary rainforest; **1 for degr areas:** primary rainforest with small open degraded areas; **Preserv for:** moist deciduous forest well preserved (secondary); **2 for frag farm wat:** secondary rainforest fragmented with small farmland, some water bodies; **Semdecfor farm wat:** semi-deciduous forest, palm oil farmland, water bodies.

Totals
[2]**A:** Total of trapped individuals of *Crossarchus* in one trapping section.
[3]**B:** Total of trapped carnivores in one trapping section.
[4]**C:** Total of trapped mammals in one trapping section.
Each 'trapping section' comprises the results from a single session (24-hr period) at a single location (defined as the operating area of a trapper, or of a group of trappers). It is believed that all individuals trapped in each trapping section were offered for visible sale, rather than there being any bias introduced through some species being consistently discarded through lack of sales or domestic value, being kept for home consumption, or being traded directly to middlemen.

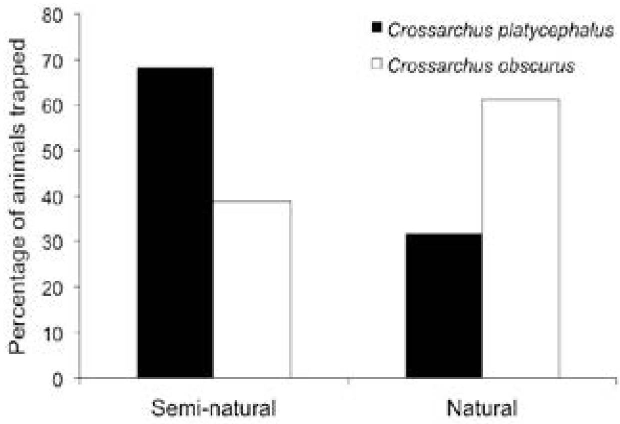

Fig. 3. Broad habitat use of Common Cusimanse *Crossarchus obscurus* and Flat-headed Cusimanse *C. platycephalus*.

records) (Fig. 3). However, the GzLM analysis shows statistically significant results for only *C. platycephalus*: its capture probability grew with decreasing elevation (B = –0.002, Wald χ^2 = 7.20, P = 0.07) and with presence of semi-natural areas (B = 0.041, Wald χ^2 = 7.15, P = 0.01).

Discussion

These preliminary results suggest that in the capture localities, both species are among the carnivores (and in the case of *C. platycephalus*, among all medium-sized mammals) most prone to capture with snares, and thus may be among the most common carnivores there (Table 1). This is consistent with perceptions that the two species are still fairly common, and with their present *IUCN Red List* category (Least Concern; see above). All this is consistent with fragmentary data previously reported on the ecology of the species (see e.g. Angelici *et al*. 1999b, Goldman 2013).

The most interesting result, albeit requiring confirmation, is the apparent greater tolerance of Flat-headed Cusimanse to partially degraded or fragmented environments, such as patches of primary or secondary forest alternating with small agricultural areas, deforested areas and also to areas of tall mangrove forest and other wetlands. Common Cusimanse appears to need less-degraded environments such as primary and secondary forests with dense undergrowth. If confirmed by further investigation, this contrasts with previous opinions that this species is rather ubiquitous (see Gilchrist *et al*. 2009, Goldman & Dunham 2013).

The habitat ranges of the two species appear similar. This may be interpreted using two hypotheses that should be investigated in the future:

a) Either the two taxa are conspecific (subspecies of *C. obscurus*). In this case the range of the two forms may be continuous, with the apparent small gap in distribution resulting from patchy survey and/or unfavourable habitats, e.g. populated coastal areas of Togo and Benin;
b) or the two taxa are different species, as some elements suggest. The two ranges seem likely to be, on current knowledge, allopatric or almost so, separated at least largely by a barrier, possibly the Volta River (geographic barrier) and/or the Dahomey Gap (ecological barrier). This region, which originated at the end of the Holocene, has for its latitude unusual environmental and climatic conditions and vegetation (Salzmann & Hoelzmann 2005) which influence the distribution and the presence of species (Booth 1958; see, e.g., Nicolas *et al*. 2010).

It would be interesting to examine in more detail the various aspects of the two taxa's ecology (e.g. diet; space and habitat use). It is desirable to promote further research in the Dahomey Gap region, where at least one of the two species is present (Raynaud & Georgy 1969, Djagoun & Gaubert 2009, Djagoun *et al*. 2009).

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Probable records of Pousargues's Mongoose *Dologale dybowskii* in the Chinko/Mbari drainage basin, Central African Republic

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Abstract

Little information is available about the biology, behaviour and habitat of Pousargues's Mongoose *Dologale dybowskii*, a species which is known only from museum specimens and a few sightings. During 2009–2012, suspected living Pousargues's Mongooses were sighted several times in the Chinko/Mbari drainage basin in Central African Republic. This report holds the first images of the Mongoose in its habitat, and covers all physical, behavioural and ecological attributes observed.

Keywords: camera-trapping, habitat analysis, *Helogale parvula*, Herpestidae, new record

Des observations probables de la Mangouste des savanes *Dologale dybowskii* dans le bassin de drainage de Chinko/Mbari, en République centrafricaine

Résumé

Peu d'information est disponible sur la biologie, le comportement et l'habitat de la Mangouste des savanes *Dologale dybowskii*, une espèce qui est connue seulement par l'entremise de spécimens de musées et de quelques observations. De 2009–2012, des individus vivants de ce que nous suspectons être la Mangouste des savanes ont été observés à plusieurs reprises dans le bassin de drainage de Chinko/Mbari, en République centrafricaine. Cette note livre les premières images de cette Mangouste dans son habitat, et reporte toutes les caractéristiques physiques, comportementales et écologiques qui ont pu être observées.

Mots clés: analyse de l'habitat, *Helogale parvula*, Herpestidae, nouvelle observation, piégeage photographique

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Pousargues's Mongoose *Dologale dybowskii* is endemic to Central Africa and is presumed rare. Scientific knowledge of this small carnivore is restricted to 31 specimens stored in museum collections, limited scientific drawings and a few reliable sightings, none of which occurred in the past 20 years (Stuart *et al*. 2008).

Due to political strife and low accessibility, the east of the Central African Republic (CAR) belongs to one of the least scientifically investigated areas of Earth today. As a result, there is a striking deficiency of data for organisms restricted to this region. The possible distribution of *D. dybowskii* proposed by Stuart *et al*. (2008) includes eastern CAR. Thanks to the fortunate collaboration with "Central African Wildlife Adventures", a local hunting safari company, access to this region was obtained.

In April 2012, while conducting a large-mammal study in the Chinko/Mbari drainage basin in CAR (Fig. 1), TA and RH asked hunting guides and locals for possible *D. dybowskii* sightings, and were then informed by AP (a hunting guide) of his sightings of an undetermined brownish mongoose that was distinctly smaller than the other mongooses of which he knew. He had made several sightings (Table 1) during his four years in the area, and had taken pictures in late 2011 (e.g. Fig. 2). Based on this information, we investigated the area in which AP reported the mongoose. We dedicated three full days of observation and mounted spare camera-traps for weeks. However, there were no further records of the mysterious mongoose until the very end of the large mammal survey in April 2012 (Table 1). We then filmed (see Table 1 for links) and took pictures of what was most likely to be one single individual, and observed it for several minutes. To learn more about its behaviour, we mounted camera-traps (e.g. Fig. 3) covering all holes of the abandoned termite mound (Fig. 4) that the individual was sighted in and around.

According to the literature, the most obvious and particular physical characteristics of *D. dybowskii* are its small size (body length: 22–33 cm; tail length: 16–23 cm), thick and bushy tail, powerful claws on the forefeet – associated with digging – and prominent reverse cowlick of fur on the throat (Kingdon 1997: 244). Our observations took place under various light conditions, but the mongoose observed appeared short legged, small bodied and very dark, with a short bushy tail. Claws on the forefeet seemed very massive and powerful, as can be seen on one camera-trap picture (Fig. 3). Estimated measurements obtained from that picture with the open source software "ImageJ" using a scale bar are: head length (8 cm), ear opening–nose tip (6 cm), eye–nose tip (3 cm) and shoulder height (11.5 cm).

The combination of characteristics of the observed individual strongly indicates Pousargues's Mongoose, differentiating it from other mongoose species potentially in the area. The similar small sympatric Common Slender Mongoose *Herpestes sanguineus* has a longer and much thinner tail and overall body appearance. The body, tail and legs of Marsh Mongoose *Atilax paludinosus*, Egyptian Mongoose *H. ichneumon*, White-tailed Mongoose *Ichneumia albicauda* and Long-nosed Mongoose *H. naso* are much larger than that of the observed animal, and additionally the tails of *H. ichneumon* and *H. sanguineus* have conspicuous black tassels, obviously absent in the observed animal. In fact, the observed animal resembled and behaved similarly to the better-known Common Dwarf Mongoose *Helogale parvula*. Common Dwarf Mongoose has a groove on the upper lip and strong teeth, characteristics not shown by *D. dybowskii* (Kingdon 1997). These features could not be checked on the observed animal, so the possibility that

Table 1. Records of probable Pousargues's Mongoose *Dologale dybowskii* in the Chinko/Mbari drainage basin, Central African Republic, 2009–2012.

Observer[1]	Date	Time	Location	Number of animals[2]	Device[3] (distance)	Material
AP	2009	Not recorded	apprx. 6°48′N, 24°00′E	1	Eye	-
AP	20 Dec 2011	11h00–11h30	6°21′10.80″N, 24°00′25.92″E	10–12	Tele-objective, eye (5 m)	Fig. 2
TA	25 Apr 2012	17h30–17h45	6°22′01.74″N, 23°59′11.28″E	1*	Telescope, binoculars, video, eye (7 m)	video[4]
TA+RH	26 Apr 2012	05h15–07h00	6°22′01.74″N, 23°59′11.28″E	1*	Telescope, binoculars, eye (18 m)	-
TA+RH	26 Apr 2012	09h30	6°22′01.74″N, 23°59′11.28″E	1*	Camera-trap (1 m)	Fig. 3

[1]Observers: AP, Adam Parkison; TA, Thierry Aebischer; RH, Raffael Hickisch
[2]*probably the same individual in all three sightings.
[3]Device: binoculars, Swarovski SLC 10×42; telescope, Swarovski ATM HD 20–60×80; camera-trap, Bushnell TrophyCam; eye: unaided eyesight; tele-objective: 400 mm Nikon Coolpix AW100 camera, through the telescope.
[4]On: http://db.tt/vpz4OOty and: http://db.tt/e1NU2YU7

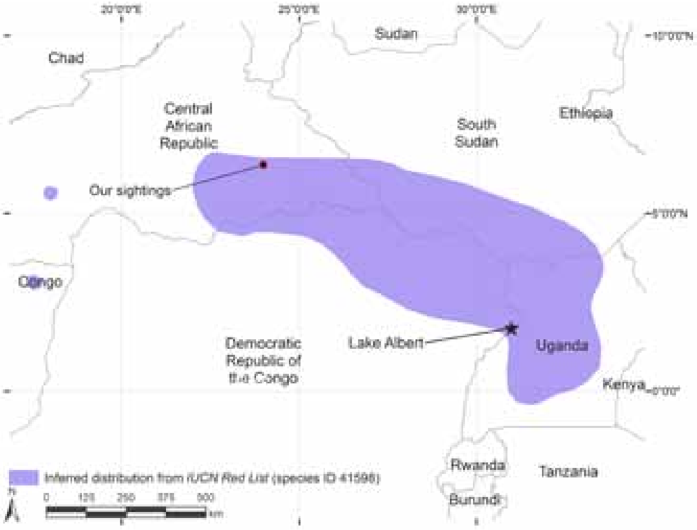

Fig. 1. Pousargues's Mongoose *Dologale dybowskii* possible distribution according to *The IUCN Red List of Threatened Species* (Stuart *et al*. 2008; available via http://bit.ly/dodydist), and localities mentioned in the text.

Fig. 2. First recorded photograph of live presumed Pousargues's Mongoose *Dologale dybowskii*: 20 December 2011, within 11h00–11h30, at 6°21′10.80″N 24°0′25.92″E in the Central African Republic (Photo: A. Parkison).

Fig. 3. Presumed Pousargues's Mongoose *Dologale dybowskii* caught on a Bushnell TrophyCam camera-trap: 26 April 2012, 09h30, at 6°22′01.74″N 23°59′11.28″E in the Central African Republic (Photo: T. Aebischer and R. Hickisch).

Fig. 4. Area around the abandoned termite mound where the presumed Pousargues's Mongoose *Dologale dybowskii* was sighted in late April 2012, in the Central African Republic (Photo: T. Aebischer and R. Hickisch).

it was a Common Dwarf Mongoose cannot be ruled out. However, according to published distribution maps of *H. parvula* (e.g. Kingdon 1997, Gilchrist *et al*. 2009), this seems very unlikely and indeed the obvious similarity of *H. parvula* with the observed small mongoose paradoxically supports the identification of the latter as *D. dybowskii* (P. Schmid verbally 2012). Additional distinctions, particularly from small *Herpestes* species, that could not be evaluated from these photographs include a shorter palate and weaker teeth (Kingdon 1997).

The region where the suspected Pousargues's Mongoose was sighted is a mosaic of tropical wet savannah and deciduous tropical lowland rainforest. Fig. 5 indicates the specific

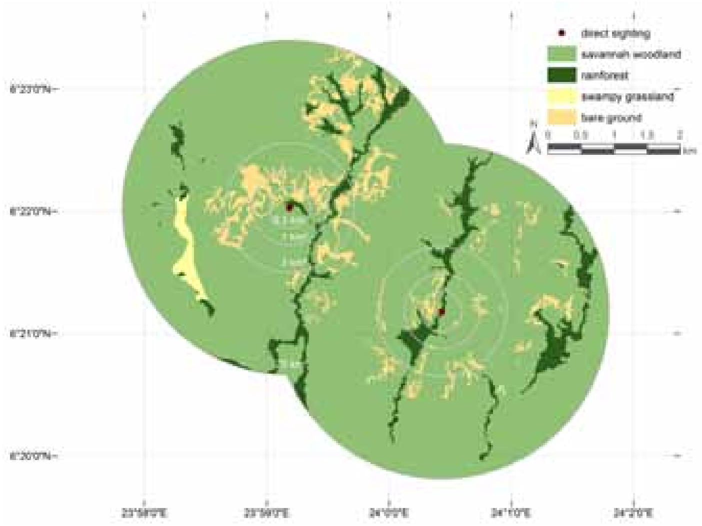

Fig. 5. Habitat around presumed Pousargues's Mongoose *Dologale dybowskii* sightings in December 2011 and April 2012 in the Central African Republic (map available at http://bit.ly/dodyhabitat).

habitat around the locations where individuals were sighted during 2009–2012 (Table 1). Savannah woodland was the most abundant habitat type, containing 87% of the surface on a larger scale around the abandoned termite mounds of the two locations. True forests and bare ground of white clay made each only around 6% of this area. Swampy grassland was the least frequent vegetation type with only 1%. No previous habitat study of *D. dybowskii* has been published, although some individuals were observed in thick riparian vegetation on the border of Lake Albert (Democratic Republic of the Congo and Uganda), and others in mountain forest grasslands (Stuart *et al*. 2008) (Fig. 1). Based on the latter records and what is known of the behaviour of other mongoose species, Kingdon (1997) concluded that *D. dybowskii* is a diurnal species occurring in the moist savannahs and edges of tropical rainforests in Central Africa north of the equator.

Given its small size and the savannah's strong daily temperature fluctuations, it is reasonable to assume that *D. dybowskii* thrives in a shelter that protects it from larger predators and the unfavourable climatic conditions. In our case, several signs or observations of the Mongoose suggest that it might have been inhabiting the abandoned termite mound at and around which it was observed: 1) bite marks and damage to and on various plants near the mound; 2) a particularly strong, 'small-carnivore-like' odour close to the mound's holes; 3) when disturbed by the observer, the Mongoose ran systematically very quickly to the termite mound to take shelter.

To conclude, this represents the first possible, scientifically-based record of *D. dybowskii* in more than 20 years (see Stuart *et al*. 2008). This does not necessarily mean that *D. dybowskii* is extremely rare. The paucity of recorded information could simply be linked to the species's geographical distribution and/or naturally elusive behaviour. Today its suspected habitat correlates with politically unstable regions and very remote areas where wildlife can only be surveyed under extremely difficult conditions. Despite this, further research in the Chinko/Mbari basin is planned, and should hopefully allow for future scientific investigations on Pousargues's Mongoose.

Recommendations for further research on alleged *D. dybowskii* individuals include more data on their biology and behavioural ecology (i.e. life history parameters, diet, social and spatial organisation, etc.) and physical characteristics (i.e. weight, exact body measurements, presence of a reverse cowlick of fur on the throat, absence of a groove on the upper lip, weak teeth, etc.), to provide a more comprehensive diagnosis and understanding of this mongoose species.

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AFRICAN SMALL CARNIVORES

Top: Servaline Genet *Genetta servalina* (L. Bahaa-el-din/Panthera)

Row 1 (L to R): African Palm Civet *Nandinia binotata* (Photo: L. Bahaa-el-din/Panthera); Miombo Genet *Genetta angolensis* (Photo: C. Fischer, R. Tagand & E. Emery); African Civet *Civettictis civetta* (Photo: L. Bahaa-el-din/Panthera)

Row 2 (L to R): Marsh Mongoose *Atilax paludinosus* (Photo: L. Bahaa-el-din/Panthera); Black-legged Mongoose *Bdeogale nigripes* (Photo: L. Bahaa-el-din/Panthera); Common Dwarf Mongoose *Helogale parvula* (Photo: E. Do Linh San)

Row 3 (L to R): Common Slender Mongoose *Herpestes sanguineus* (Photo: E. Do Linh San); Egyptian Mongoose *H. ichneumon* (Photo: T. Bohm); Long-nosed Mongoose *H. naso* (Photo: L. Bahaa-el-din/Panthera)

Left: Meerkat *Suricata suricatta* (Photo: E. Do Linh San)

Bottom: Honey Badger *Mellivora capensis* (Photo: L. Bahaa-el-din/Panthera)

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