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# MAMMAL DIVERSITY SURVEYS IN THE COASTAL FORESTS: KENYA

2010 – 2011

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**In memory of Dr Sam Andanje, a close friend and highly gifted scientist who tirelessly worked on conserving wildlife in Kenya**

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# ABSTRACT

This report summarises results of a year-long camera-trapping study of four coastal forest sites on the north Kenya coast. Systematic 2 x 2 km grid layouts were deployed using a standardised camera-trap protocol for long-term monitoring, and placed consecutively in each of Dodori National Reserve (NR), Boni NR, Boni forest (all north of the Galana and Tana rivers) and at Arabuko-Sokoke Forest. These sites are all representative of the Coastal forests of Eastern Africa biodiversity hotspot. Prompted by the rediscovery of Aders' duiker and an unknown form of giant sengi during pilot studies in the three northern most coastal forests, the objective was to use camera-trapping to make the first comprehensive study of the medium-to-large sized mammal communities of the northern group of forests (the Boni-Dodori forest system) which have been little studied, and compare the results with a matching study in the better known Arabuko-Sokoke Forest.

The core of the report presents individual species accounts. Example photographs and brief comments on recognition in camera-trap imagery, together with IUCN Red List conservation status and notes on legal status are given. Trapping rates (events / 100 camera-trap days), naïve occupancy and where appropriate modelled occupancy are given for each species at every study site. Temporal distribution of events (which in larger samples act as a proxy for activity pattern) and map plots of trapping rate at each camera-trap are also reported.

A summary of the species accounts shows that all three northern coastal forest survey sites recorded higher terrestrial mammal species richness than Arabuko-Sokoke Forest (29 species in Boni NR; 32 species in Dodori NR; 26 species in Boni forest; 20 species in Arabuko-Sokoke Forest). The relationship holds true after standardising comparison to species of similar detectability to camera-traps. In all but one case (blue duiker), camera-trapping rates and occupancy were higher, often much higher, in the northern coastal forests than at Arabuko-Sokoke Forest for species found in both areas. Significantly Arabuko-Sokoke Forest remains of high importance in sharing the same number of truly coastal forest adapted species, as the three northern coastal forests.

New findings on species distributions and range extensions, notable indications of relative abundance and presence of species under threat are reported. The relatively intact nature of the northern coastal forests mammal community is highlighted. Among several notable results: the unknown giant sengi found north of the Tana River is shown to be present at all three sites and is detected at higher frequency than the golden-rumped sengi is in Arabuko-Sokoke Forest. The Boni-Dodori forest system also emerges as the global centre for the Critically Endangered Aders' duiker, unexpectedly the most frequently reported species in the northern coastal forest camera grids.

Principle conclusions and recommendations are:

- the Boni-Dodori forest system is of major importance to mammal conservation within the Eastern African coastal biodiversity hotspot with relatively undisturbed and complete communities of predators and herbivores;

- that this status is recognised and incorporated into future land use planning, with a focus on finding ways for the local communities to integrate development of the region while sustaining and gaining benefit from this unique heritage.

# 1. INTRODUCTION

The biodiversity of northern coastal Kenya is poorly understood because recent security problems and poor infrastructure have discouraged access to the area. However, the wooded areas in the region have great potential for harbouring unique and rare species. The presence of Aders' duiker (*Cephalophus adersi)* (Andanje et al. 2011a), the additional recent discovery of an unknown form of giant Sengi (*Rhyncocyon sp.*) (Andanje et al. 2010) and the presence of other species of high conservation interest, such as African wild dog (*Lycaon pictus*) (Githiru et al. 2008), prompted the need for a systematic baseline study of mammal species richness and status for the Boni-Dodori forests using camera-traps.

The use of camera-trapping as a survey tool for medium-to-large terrestrial mammals has become increasingly common over recent years (Ahumada et al. 2011; O'Connell et al. 2011) and is a particularly suitable technique for longer term monitoring in forest habitats (Silveira et al. 2003; Gompper et al. 2006; Lyra-Jorge et al. 2008; Robert 2011; Amin et al. 2015). In order to interpret our results in a national context we also surveyed the Arabuko-Sokoke Forest. As well as being the best known coastal forest protected area in Kenya, Arabuko-Sokoke Forest is well-known for the endemic golden-rumped sengi and as the only mainland inhabited by Aders' duiker.

The combined results provide baseline data on the forest adapted mammal populations in this highly threatened east African coastal forest system. They also provide a basis for a long term monitoring program in the future. The analysis presented can be replicated as a standardised monitoring method. The approach can provide efficient quantitative measures of biodiversity status over time for a range of key but otherwise elusive forest species. Such measures would play an important role in demonstrating the success of conservation action plans for the national reserves if repeated systematically.

## 1.1 Study area

The wooded habitats of coastal Kenya form part of the Coastal Forests of Eastern Africa biodiversity hotspot, an area known for globally significant levels of species richness and endemism (Burgess and Clarke 2000; Mittermeier et al. 2005). Much of this habitat in Kenya has been cleared for coastal development and agriculture (Mittermeier et al. 2005), however, several protected areas exist along the northern Kenyan coast (Table 1). Boni and Dodori National Reserves (NRs), in Ijara and Lamu East Districts respectively, were gazetted in 1976. They lie adjacent to the Boni forest and these three areas, referred to henceforth as the 'Boni-Dodori forest system', form a cluster on the northern Kenyan coast (Figure 1). The remote location and history of insecurity have resulted in a comparatively low human population density and minimal development. Four principle villages, occupied by the Aweer people, are located along a bush track running between the Boni and Dodori NRs, although the exact location of the gazetted boundaries remains uncertain.

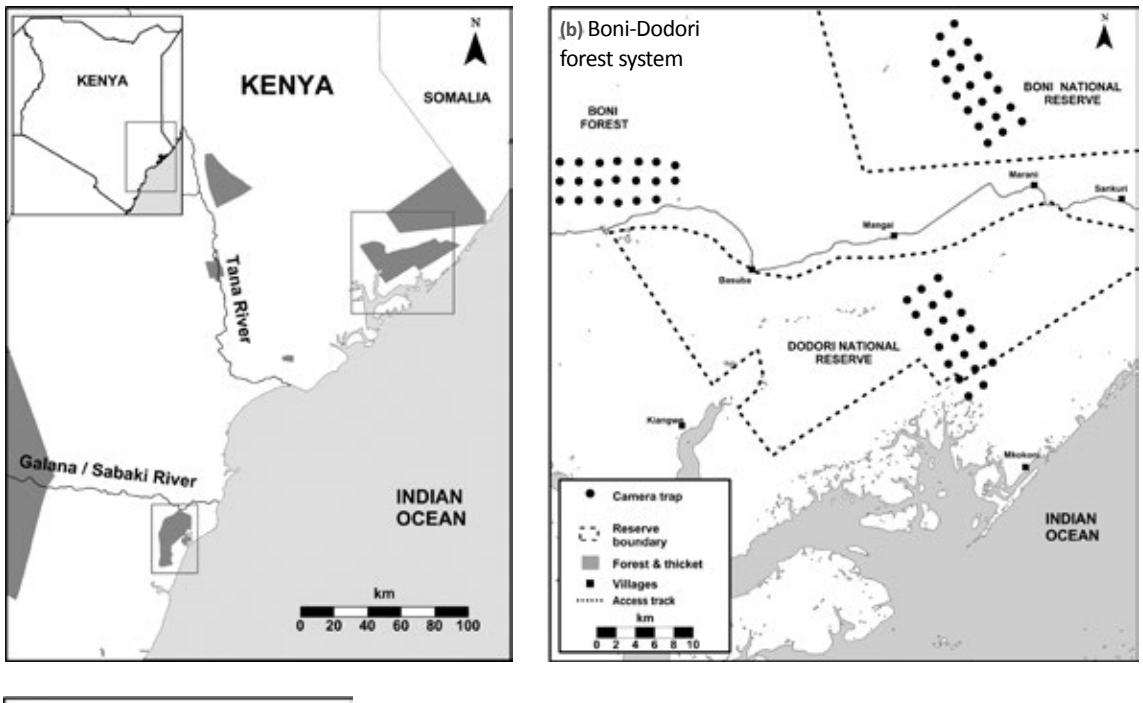



**Figure 1** Location of four study areas in central and northern coastal Kenya; insets show location of camera-trap arrays relative to protected area boundaries at Arabuko-Sokoke Forest (a) and Boni-Dodori forest system (b).

The Arabuko-Sokoke Forest, established in 1932, is 250 km to the south of the Boni-Dodori forest system in Kilifi County. It is separated from the northern Kenyan coastal forests by two major intervening rivers, the Tana and Galana/Sabaki (Figure 1). It is completely encircled by un-clustered village settlements comprising an estimated total human population greater than 100,000 individuals (ASFMT 2002). Both study areas experience illegal hunting and timber extraction, with impact of these activities likely to be much higher in the smaller Arabuko-Sokoke Forest, which is exposed to comparatively high human population densities.

**Table 1** Summary data on legal status, size, location and sampling period for the four camera-trapping grids.

| Sample area status | Size ($km^2$) | Established | Camera-trap grid central point | Camera-trap sampling period |
|---|---|---|---|---|
| Dodori National Reserve | 877 | 1976 | 1°49.31'S, 41°04.47'E | 14 Jan to 16 Mar 2010 |
| Boni National Reserve | 1,339 | 1976 | 1°32.22'S, 41°19.53'E | 17 Mar to 16 Jun 2010 |
| Boni forest | 450* | Not applicable | 1°40.5'7'S, 40°52.53'E | 19 Jun to 06 Sep 2010 |
| Arabuko-Sokoke National Reserve | 420 | 1932 | 3°21.34'S, 39°50.35'E | 01 Oct 2010 to 21 Jan 2011 |

* Area approximated as no formal boundary has been established

Habitat in the Boni-Dodori forest system consists of a mosaic of forest, thicket and savannah (Kuchar and Mwendwa 1982). Arabuko-Sokoke Forest is forested with three main vegetation types: *Cynometra* forest and thicket, *Brachystegia* woodland and mixed forest (ASFMT 2002).

# 2. METHODS

## 2.1 Field sampling methods

Survey design at each forest site consisted of cameras systematically spaced at 2 km intervals on a regular 3 x 7 square grid, orientated to the available habitat patches (Figure 1). One / two km spacing is normally recommended for mammal community surveys (Amin et al. 2014).

We positioned the sampling grids of cameras in extensive areas of forest and thicket based on habitat and accessibility. ArcGIS 9.3 (ESRI, Redlands, CA USA) software and GPS receivers were used to locate camera sampling unit centre points. A single camera-trap was placed within 100 m of each centroid under closed canopy forest or thickets. We set the cameras at a height of 30–45 cm, positioned perpendicular to game trails at a distance of c. 4-8 m with the aim of obtaining full body lateral images of small antelopes and other mammal species. We used Reconyx RM45 (RECONYX, Inc., Holman, WI, USA) digital cameras, programmed to take three pictures per trigger with no delay. All other default settings were used. RM45 cameras have a trigger time of 0.1 s with a detection range of 25+ m. All images were in black and white. These cameras use an infrared flash at night (or at low light levels in the day time), intended to minimise risk of startling animals when they enter the camera view. Each survey was conducted for a minimum of 50 days in order to achieve 1,000 camera-trap days of sampling effort (O'Brien et al. 2003) with 20 fully functioning cameras. The camera installation protocol called for survey teams to trigger photographs of themselves as the last action at the end of camera set up operations and as the first action on arrival to recover cameras, as a means to help verify camera function.

## 2.2 Analytical methods

### Data compilation and processing

We used Exiv2 software tool (Huggel 2012) to extract image metadata. The camera-trap label, date, time and temperature were compiled for each image in an excel sheet (Microsoft Office Professional Plus 2010). All photographs were classified to species, and grouped into independent photographic events. For this study an 'event' was defined as any sequence of photos from a given species occurring after an interval of ≥ 60 minutes from the previous images of that species (Amin et al. 2014). Identification of species was mostly straight forward. Distinguishing species under infrared illumination was sometimes unclear, especially blue duiker *Philantomba monticola* from suni *Nesotragus moschatus*. Behavioural features such as differences in tail movement (e.g. flicked laterally in suni, vertically in blue duiker, Foley 2008) were sometimes useful in such cases. The white rump-band and leg-spots of Aders' duiker, key distinguishing features, were sometimes partially or strongly obscured in infra-red illuminated black and white images (Figure 2). It was also difficult to distinguish between Four-toed sengi (*Petrodromus tetradactylus*) and Rufous sengi (*Elephantulus rufescens*). Multiple images at each trigger allowed cross-checking and verification. However a few images attributed to blue duiker or suni had to be excluded from our analysis as positive identification was not possible.


**Figure 2** Camera-trap images of Aders' duiker at one location in Boni NR labelled by date and time. Adult female and calf (left) and adult male (right). Note established scent mark (dark patch just below the fork on the sapling), effect of infrared illumination on duiker appearance (lower images) and role of spot pattern on legs for individual recognition.

## Species richness

We used the ZSL Camera-trap analysis tool (Amin et al. *in prep*) with the "BiodiversityR" package in R software program (Kindt and Coe 2005) to estimate species richness of medium-to-large terrestrial mammals (weighing greater than 0.5 kg) in each forest site. We excluded arboreal species as they are less likely to be captured by cameras directed at ground level. We excluded species <0.5 kg because their small size results in reduced and inconsistent capture probabilities. This defined subset of species of approximately similar detectability provides a consistent measure of mammal species richness for each site which through replicate surveys provides trends in species composition and richness over time. We obtained rarefied accumulation curves for each species in each forest site by randomly re-sampling the data and calculating the average number of species expected to be found at a given sampling intensity. This curve reaches an asymptote when all species from the focal group or taxa have been recorded. As some species go undetected even though they are present in the study area we used the non-parametric incidence-based estimator Jackknife with order one (Jackknife 1) to estimate the true number of species. Jackknife 1 gives the most reliable estimate for large numbers of camera days (Tobler et al. 2008). Jackknife estimators also assume that the community composition does not change over the time of the study (closure), and that there is no temporal variation in capture probability for all species (Burnham and Overton 1979; Chao 2004). With a survey length of approximately 60 days, these assumptions should be met.

## Species distribution

We used single season occupancy analysis (MacKenzie et al. 2006) to estimate the proportion of area occupied by a species (ψ), in each of the four forest sites. Occupancy of each species was analyzed separately within the ZSL Camera-trap analysis tool using the package unmarked package in R software (Fiske and Chandler 2011). We grouped samples (days) into ten-day sampling occasions to improve detection probability of the rarer species and constructed detection (1), non-detection (0) history for each species per study site. We also calculated naıve occupancy which is defined as the number of cameras at which a species is detected divided by the total number of operational cameras.

Occupancy can also be used as a surrogate for species abundance if the inter-trap distance is greater than the home range of the species. Forest antelope species and the other small-to-medium mammal species found in these forests have relatively small home ranges. Documented small forest antelope home range sizes vary between suni (0.5 - 4 ha, Kingdon and Hoffman 2013) and white-bellied duiker (*Cephalophus leucogaster*) (63 ha, Hart 2013). Consequently with camera-trap spacing of 2 km we can assume that each individual is likely to appear only in one camera-trap.

To assess area of forest habitat in the northern forest zone we obtained two Landsat images (30 m resolution) for the scene, Path 165, Row 061 (March 2009 and March 2010), covering the northern coastal forests. We selected the most cloud free images during the dry season to classify the habitat into grassland and forest cover. For each image, we used knowledge based methods (Meng et al. 2009) to classify cloud cover and shadows as ''No Data'' in IDRISI Kilimanjaro software (Eastman 2004). We then used the spatial analyst extension in ArcGIS version 10.1 and performed unsupervised classification using a cluster algorithm, generating 20 spectral clusters. These data were stratified into 'zones', where land cover types within a zone have similar spectral properties collapsing the 20 spectral classes identified in the cluster analysis into a raster image with the three classes (forest and thickets, non-forest and water) (Kuemmerle et al. 2009; Baumann et al. 2012).

The resulting classified images were interpreted visually using the Landsat images, and, where available, high-resolution QuickBird imagery from Google EarthTM (Kuemmerle et al. 2009; Baumann et al. 2012). Using the boundary clean tool in ArcGIS Spatial Analyst, we removed the remaining correction errors and converted the raster images into vector datasets (polygon). We further simplified the polygon dataset using the dissolve tool in ArcGIS data management tool. Using the mosaic tool in ArcGIS data management tool, we combined the two images into one new image resulting in a complete current vegetation map of the area. We used the existing vegetation 'shape' file from the KWS GIS Department for Arabuko-Sokoke Forest classified into *Cynometra* forest, *Brachystegia* forest, mixed forest and other vegetation. We represented species presence as circles weighted by trapping rate overlaid on each camera location.

## Species abundance

We used the mean number of independent photographic events per trap day x 100 (trapping rate) as a relative abundance index (RAI). RAI is primarily useful for within species comparisons under standardised conditions, but differences in species biology and detectability mean that its use in between species comparisons is limited. We computed the standard error of RAI as the standard deviation of the trapping rate divided by the square root of the number of trap days and applied the Wald test to test for significant difference. To obtain an estimate of the population density of the Critically Endangered Aders' duiker, across all sampling units we applied an N-mixture model, (developed for estimating population size from spatially replicated counts (Royle 2004)), available in the software Presence 3.1 (Hines 2006). The camera-trap data were adapted to mimic a set of replicated counts by selecting a one-hour period of maximum activity from the derived 24 hour activity pattern and dividing this into six 10-minute occasions. We created a count matrix of the number of individuals detected in the camera-trap images within each 10 minute occasion at each sampling unit of Boni NR camera-trap grid for Aders' duiker. We could not apply the method to Arabuko-Sokoke Forest camera-trap data for comparative analysis as the number of Aders' duiker encounters was very low. We obtained a density estimate by dividing the estimated number of adult individuals by the number of sampling units multiplied by the estimated average home range. Detailed results of these analyses have been published separately (Amin et al. 2014).

## Species behaviour

We used the number of independent photographic events per hour to compile 24 hour activity patterns for each species. We also performed circadian activity pattern comparisons between forest specialist antelope species including the Critically Endangered Aders' Duiker. As the forest antelopes involved in this study are mainly crepuscular / diurnal (Kingdon and Hoffman 2013), we compiled photographic events into four six-hourly time periods; 03:00-09:00, 09:00-15:00, 15:00-21:00 and 21:00-03:00. We also compared day (04:00 – 20:00) and night (20:00 – 04:00) activity patterns. We analysed the activity patterns using *Oriana* circular statistics program (Kovach 2011) using pair-wise Chi-squared test to test for significance. The main results of these analyses and the spatial interaction comparisons have been published separately (Amin et al. 2014).

# 3. RESULTS

## 3.1 Sampling effort

The four surveys were phased consecutively over one year and each camera-trap grid was left in the field for 60-111 days with a mean sampling effort of 1,430 camera-trap days per survey (range 1,026 – 1,940). Camera-trap days were calculated as the total number of 24 hour periods each camera was operating normally. Camera attrition and failures resulted in 13-20 useable locations across the four sites (Table 2).

**Table 2** Sampling effort in the four Kenyan coastal forests.

| Survey site | No. of deployed cameras (No. of functioning cameras) | No. of camera-trap days |
|---|---|---|
| Boni NR | 20 (19) | 1,670 |
| Boni forest | 20 (13) | 1,026 |
| Dodori NR | 20 (20) | 1,087 |
| Arabuko-Sokoke Forest | 21 (18) | 1,940 |

## 3.2 Mammal diversity

The overall results are summarised in Table 3. A total of 38 mammal species were photographed in the northern coastal forests (29 species in Boni NR; 32 species in Dodori NR and 26 species in Boni forest); and 20 species in Arabuko-Sokoke Forest (Table 3). This includes the Aders' duiker ('Critically Endangered' under the IUCN Red List criteria); the African wild dog ('Endangered' under the IUCN Red List criteria), a potentially new species of giant elephant shrew and an unidentified squirrel. Although we were unable to distinguish between Four-toed sengi (*Petrodromus tetradactylus*) and Rufous sengi (*Elephantulus rufescens*) in the images, we have assumed the presence of both species in the four forest sites (Andanje et al. 2010). We excluded murid species as they were difficult to identify and assumed to be of erratic detectability.

There were 25 and 16 terrestrial mixed-forest specialist species in the northern coastal forest system and Arabuko-Sokoke Forest respectively. Of these 23 species are greater than 0.5 kg body weight in northern coastal forests and 14 species in Arabuko-Sokoke Forest; the main target group for camera-traps placed at ground level in forest (Tobler et al. 2008).

Dodori NR had much higher medium-to-large terrestrial mammal species richness (34) and Arabuko-Sokoke Forest the lowest with 18 species (Table 4). The species accumulation curves for medium-to-large (> 0.5 kg) terrestrial forest dependent mammal species show that it takes about 500 camera days to obtain a record of the most common species (Figure 3). It is the more elusive species that determine how much time is needed to complete such a survey. The three northern coastal forest sites have similar estimated number of forest dependent species (>0.5 kg) (20-21) compared to 16 forest species in Arabuko-Sokoke Forest.

Annex-I provides the regional medium-to-large mammal species list for northern coastal Kenya based on results of camera-trapping across all four grids, supplemented by species expected to be present in the region according to IUCN Red List distribution maps.

**Table 3** Mammal species list recorded in the northern Kenyan coastal forests and Arabuko-Sokoke Cynometra forest (for comparison).

| | Family | Species | Common name | CT grid presence | IUCN status | Habitat | Habit | Wt. kg (M,F, Avg.) |
|---|---|---|---|---|---|---|---|---|
| 1 | Viverridae | *Civettictis civetta* | African Civet | D | LC | M | T | 10.9, 11.6, 11.3 |
| 2 | Viverridae | *Genetta maculate* | Central African Large Spotted Genet | B,D,BF,A | LC | FS | T/Ar | 1.9, 1.7, 1.8 |
| 3 | Felidae | *Panthera pardus* | Leopard | B,D,BF | NT | M | T/Ar | 51.4, 32.9, 42.2 |
| 4 | Felidae | *Panthera leo* | Lion | BF | V | M | T | 155.5, 111, 133.3 |
| 5 | Felidae | *Felis caracal* | Caracal | B,D,A | LC | M | T | 12.9, 10, 11.5 |
| 6 | Hyaenidae | *Crocuta crocuta* | Spotted Hyena | B,D,BF | LC | M | T | 48.4, 55.6, 52 |
| 7 | Canidar | *Lycaon pictus* | African Wild Dog | B | EN | M | T | 22.7, 22.7, 22.7 |
| 8 | Herpestidae | *Helogale parvula* | Common Dwarf Mongoose | B,D,BF,A | LC | B-G | T | 0.269, 0.265, 0.270 Assumed to be H. parvula from the IUCN species range map, identification (H.parvula or H. hirtula) from images was not possible |
| 9 | Herpestidae | *Atilax paludinosus* | Marsh Mongoose | D | LC | SA | T/Aq | 3, 2.6, 2.8 |
| 10 | Herpestidae | *Herpestes sanguinea* | Slender Mongoose | D,BF | LC | M | T | 0.637, 0.459, 0.550 |
| 11 | Herpestidae | *Bdeogale omnivore* | Sokoke Bushy Tailed Mongoose | B,D,BF | V | FS | T | 1.2 |
| 12 | Herpestidae | *Ichneumia albicauda* | White Tailed Mongoose | B, A | LC | M | T | 4.49, 4.14, 4.32 |
| 13 | Mustelidae | *Mellivora capensis* | Honey badger | B,D,BF,A | LC | M | T | 11.7, 9.5, 10.6 |
| 14 | Macroscelidinae | *Petrodromus tetradactylus* | Four-toed Sengi | B,D,BF,A | LC | FS | T | 0.20 |
| 15 | Macroscelidinae | *Elephantulus rufescens* | Rufous Sengi | B,D,BF,A | LC | FS | T | 0.06 |
| 16 | Rhynchocyoninaeae | *Rhynchocyon sp.* | Golden-rumped Elephant Shrew | A | EN | FS | T | 0.54 |
| 17 | Rhynchocyoninaeae | *Rhynchocyon sp.* | Giant Sengi (Dark rumped) | B,D,BF | EN | FS | T | 0.6 (one voucher specimen - potentially new species) |
| 18a | Cercopithecinae | *Cercopithecus mitis albotorquatus* | Pousargues's Sykes's Monkey | B,D,BF | LC | FS | Ar | - |
| 18b | Cercopithecinae | *Cercopithecus mitis albolgularis* | Zanzibar Sykes's Monkey | A | LC | FS | Ar | 5.7, 3.6, 4.65 |
| 19 | Cercopithecinae | *Chlorocebus pygerthrus* | Vervet Monkey | D | LC | B-G | Ar/T | 4.2, 2.7, 3.45 |
| 20 | Cercopithecidae | *Papio cynocephalus* | Yellow Baboon | B,D | LC | B-G | T | 24.9, 13.6, 19.25 |
| 21 | Galagidae | - | Galago sp. | B,A | LC | I | Ar | At least four galago species potentially present. |
| 22 | Nesomyidae | *Cricetomys gambianus* | Gambian Giant Rat | B,D,BF,A | LC | M | T/Ar | 0.79 |
| 23 | | | 1 squirrel sp. | B,BF | N/A | I | U | 0.20 |
| 24 | Sciuridae | *Paraxerus palliatus* | Red Bush Squirrel | B,D,BF,A | LC | M | T/Ar | 0.38 (average) |

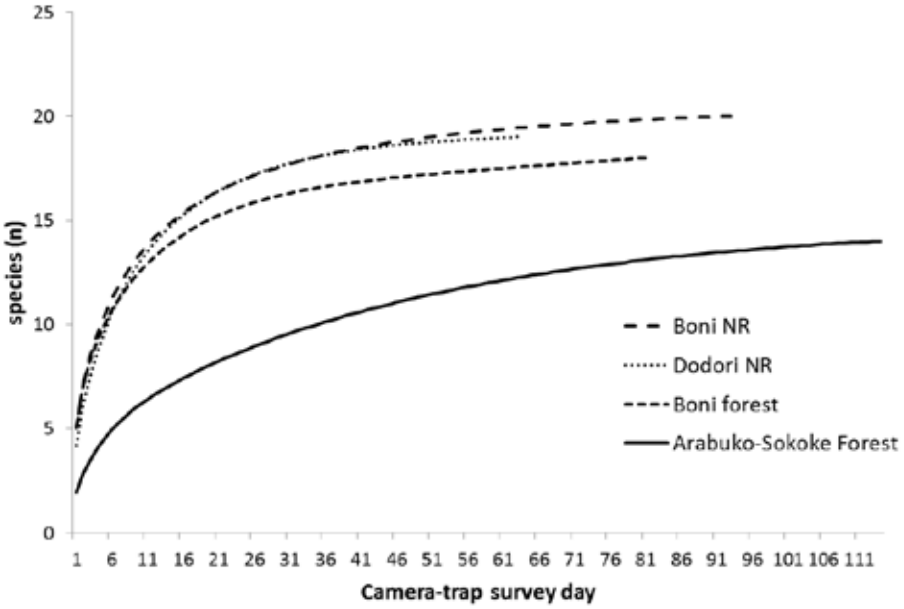
| | Family | Species | Common name | CT grid presence | IUCN status | Habitat | Habit | Wt. kg (M,F, Avg.) |
|---|---|---|---|---|---|---|---|---|
| 25 | Hystricidae | *Hystrix cristata* | Crested Porcupine | B,D,BF,A | LC | M | T | 20.00 |
| 26 | Bovidae | *Cephalophus adersi* | Aders' Duiker | B,D,BF,A | CR | FS | T | 9.2, 9, 9.10 |
| 27 | Bovidae | *Cephalophus monticola* | Blue Duiker | B,A | LC | FS | T | 4.8, 5.3, 5.05 |
| 28 | Bovidae | *Cephalophus harveyi* | Harvey's Duiker | B,D,BF,A | LC | FS | T | 11.3, 11.9, 11.60 |
| 29 | Bovidae | *Neotragus moschatus* | Suni | B,D,BF,A | LC | FS | T | 5, 5.4, 5.20 |
| 30 | Bovidae | *Madoqua sp.* | Kirk's Dik-dik | D | LC | B-G | T | 4.59, 5.17, 4.88 |
| 31 | Bovidae | *Tragelaphus imberbis* | Lesser Kudu | D | NT | B-G | T | 95-105, 80-95, 93.75 |
| 32 | Bovidae | *Tragelaphus scriptus* | Bushbuck | B,D,BF,A | LC | M | T | 42, 28, 35.00 |
| 33 | Bovidae | *Syncerus caffer* | African Buffalo | B,D,BF | LC | M | T | 750.8, 446.6, 598.7 |
| 34 | Bovidae | *Kobus ellipsiprymnus* | Waterbuck | D | LC | B-G | T | 226.6, 175.4, 201 |
| 35 | Suidae | *Potamochoerus larvatus* | Bushpig | B,D,BF,A | LC | M | T | 52, 61, 56.5 |
| 36 | Suidae | *Phacochoerus africanus* | Common Warthog | B,D,BF | LC | B-G | T | 79.6, 56.5, 68.05 |
| 37 | Suidae | *Phacochoerus aethiopicus* | Desert Warthog | BF | LC | B-G | T | - |
| 38 | Elephantidae | *Loxodonta Africana* | African Elephant | B,D,BF | V | M | T | 6048 (max), 3232 (max), 4640 |
| 39 | Hippopotamidae | *Hippopotamus amphibius* | Hippopotamus | D | V | SA | Aq/T | 1536, 1386, 1461 |
| 40 | Orycteropidae | *Orycteropus afer* | Aard-vark | B,D,BF,A | LC | M | T | 53.3, 51.4, 52.35 |

(B= Boni NR, D=Dodori NR, BF=Boni forest, A=Arabuko-Sokoke Forest). The species are grouped by trophic categories. The species average adult body mass in kilograms, IUCN status, general behavior (Ar=Arboreal, Aq, Aquatic, T=Terrestrial, U=Unknown) and habitat preference (M=Mixed, B-G=-Bush-Grassland, FS=Forest Specialist, SA=Semi-Aquatic, I=Indetermined) are also provided.

**Table 4** Species richness estimates for medium-large terrestrial mammal species and forest dependent species (>0.5 kg adult body mass) for the Boni-Dodori forest system and Arabuko-Sokoke Forest.

| Survey site | Terrestrial mammal (>0.5 kg) species Jackknife 1 estimate (no. of observed species) | Terrestrial mixed-forest specialist mammal (>0.5 kg) species Jackknife 1 estimate (no. of observed species) |
|---|---|---|
| Boni NR | 25 (23) | 21 (20) |
| Boni forest | 23 (21) | 20 (18) |
| Dodori NR | 34 (28) | 20 (19) |
| Arabuko-Sokoke Forest | 18 (15) | 16 (14) |

**Figure 3** Rarefied species accumulation curves for medium-to-large terrestrial forest dependent mammal species in Boni NR, Dodori NR, Boni forest and Arabuko-Sokoke Forest.




## 3.3 Species distribution, abundance and activity patterns

This section summarises the camera-trap survey results for each recorded species. The results are grouped by the major orders of ungulates, carnivores, afrotheria, primates and rodents. Global conservation status (IUCN Red List category) and legal status (CITES and Kenya Wildlife Act) are noted for each species. The number of events and trapping rates, occupancy estimates, activity / temporal patterns and distribution depicted on maps are provided for each species.

**Format of species accounts**

***Scientific name (Authority)***
The binomial names for species are based on international rules of zoological nomenclature.

**Common names**
English; Swahili.

**Species description**
A description of the species with reference to species identification from black and white camera-trap images.

**Global conservation status**
Global risk of extinction. Based on IUCN Red List of Threatened Species 2015.

**Legal status**
Species listed under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the Kenya Wildlife Act.

**Camera-trap survey results**
Relative abundance trapping rates for each site.

Naïve and modelled occupancy compared between sites.

Activity patterns expressed as temporal distribution of all camera-trap events over a 24 hour cycle.

Summary with local distribution maps (species presence weighted by trapping rate overlaid on each camera location); note the trapping rate (events/100 days) scale legends carefully when comparing maps between species as these vary in some cases to accommodate the wide range of trapping rates obtained.

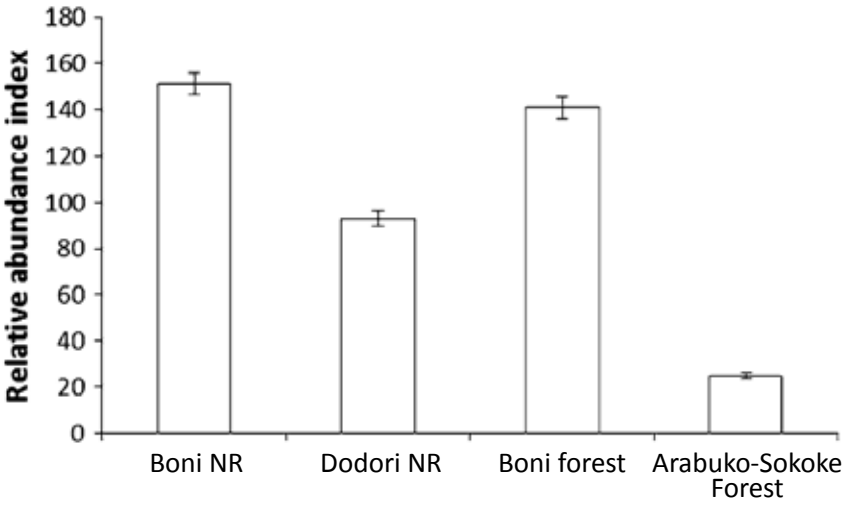
## Ungulates

A total of 13 ungulate species were recorded in the four camera grids comprising over 5,700 events across 70 camera-traps with more than 15 years of combined sampling effort. They comprise three Suidae: Bushpig, Common warthog, Desert warthog; nine Bovidae: African buffalo, Waterbuck, Bushbuck, Lesser kudu, Kirk's dik-dik and four forest adapted antelopes, Suni, Blue duiker, Harvey's duiker, Aders' duiker; and one Hippopotamidae.

Across all sites, the most frequently encountered ungulate was Aders' duiker (3,140 events) followed by Suni (2,403 events), African buffalo (129 events), Harvey's duiker (99 events), Bushbuck (63), Bushpig (33), Blue duiker (41). The remaining six ungulate species were recorded with less than 15 events each.

In general most ungulate species were recorded with higher frequencies north of the Tana River. Among forest antelopes, Suni represented 94% of the total forest adapted antelope events in the Arabuko-Sokoke Forest site, but overall trapping rate was much lower than in the three northern coastal forests (Figure 4). Importantly, occupancy estimates for the Critically Endangered Aders' duiker were at least eight times higher in the northern coastal forests than in Arabuko-Sokoke Forest. Similarly, Aders' duiker trapping rate was one to two orders of magnitude greater at all three northern coastal forest sites of the Boni-Dodori forest system compared to Arabuko-Sokoke Forest where it was only recorded on two occasions at separate camera sampling sites despite a more prolonged sampling effort. Harvey's duiker also occurred more frequently in the north. The most notable exception to this rule was blue duiker recorded in half the cameras at Arabuko-Sokoke Forest at low trapping rates, but only observed twice at one camera north of the Tana River.

**Figure 4** Relative abundance index (camera-trap events/day x 100) combined for the forest antelope species recorded at each of the four Kenyan coastal forest sites. Standard error bars are also shown.



# 1 *Cephalophus adersi*
(Thomas, 1918)

**Common names**
Aders' duiker (English); Nunga (Swahili).

**Species description**
Aders' duiker is a small to medium sized duiker weighing 6.5-12 kg. The body is primarily red/ rufous brown in colour but is immediately distinguished from other red duikers by a horizontal broad white band from its lower flanks, and thighs, meeting across the lower rump. Patchy white freckling on its lower limbs and darkening grey tone to the face and neck are also characteristic. In most black and white (infrared illuminated) images features of this pattern are evident but in a small number of cases, especially in poor light, the body may appear deceptively uniform and confusion with other small antelopes may occur.

**Global conservation status**
IUCN Red List Status: Critically Endangered.

**Legal status**
CITES: Appendix I.
Kenya Wildlife (Conservation and Management) Act: Not Listed.
African Convention on the Conservation of Nature and Natural Resources: Class A.

***Camera-trap survey results***

**Relative abundance:** Aders' duiker was the most frequently recorded antelope species in the Boni-Dodori forest system but was only recorded on two occasions, at separate camera sites, in the Arabuko-Sokoke Forest, despite greater sampling effort (Table 5).

**Table 5** Aders' duiker trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 1856 | 1670 | 111.89 (±4.12) |
| Boni forest | 616 | 1026 | 60.44 (±2.20) |
| Dodori NR | 666 | 1087 | 58.69 (±2.47) |
| Arabuko-Sokoke Forest | 2 | 2049 | 0.01 (±0.01) |

**Occupancy**: Aders' duikers were detected at all fully operational camera sites in the Boni forest camera grids resulting in occupancy estimates of 100%. Occupancy in the Dodori camera grid was estimated at 95% and occupancy for the Arabuko-Sokoke Forest camera grid could not be modelled due to the low number of detections. Naïve occupancy for the Arabuko-Sokoke Forest camera grid was 0.11% (Table 6).

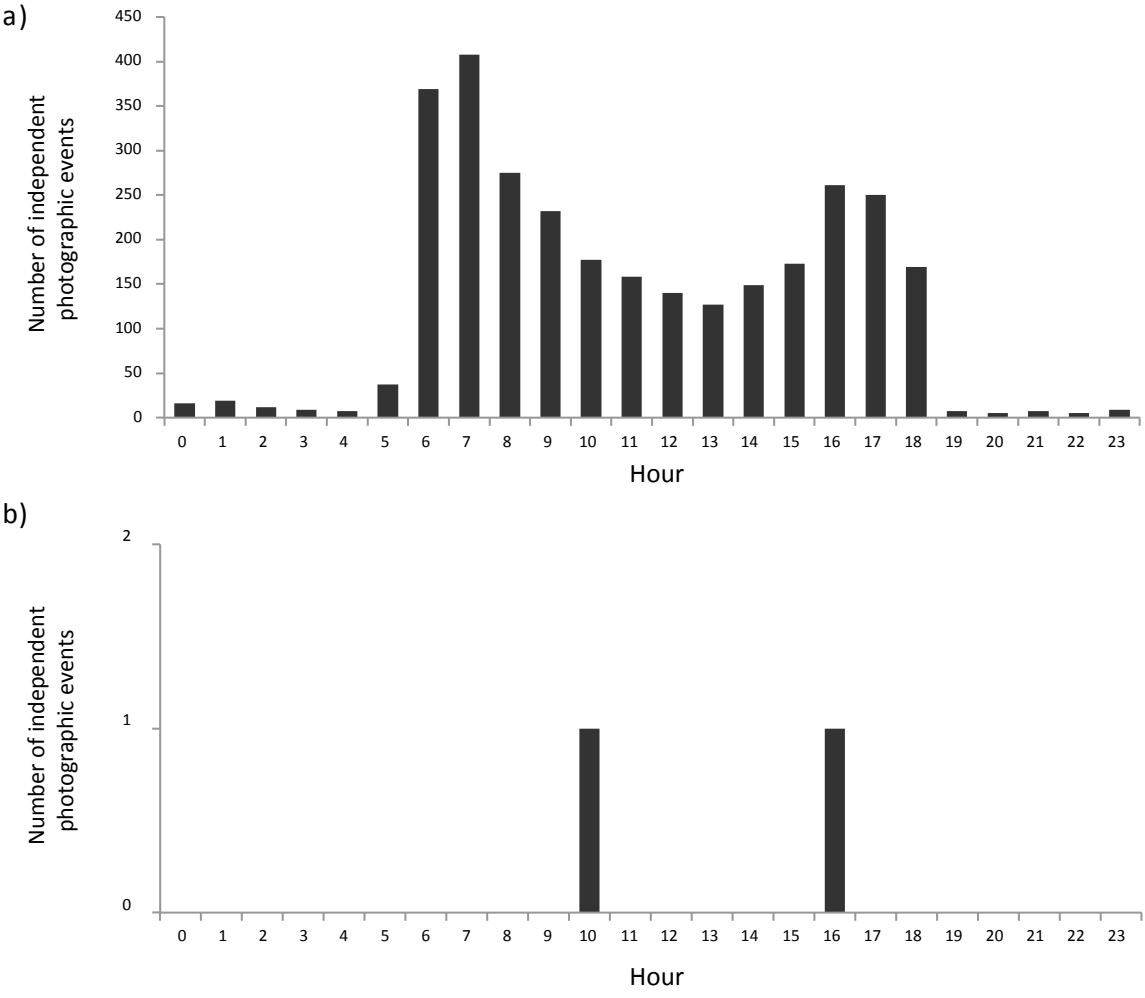
**Table 6** Naïve occupancy and modelled occupancy and detection probability estimates for the Aders' duiker in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 1.00 | 1.00 (±0.00) | 1.00 (±0.00) |
| Boni forest | 1.00 | 1.00 (±0.00) | 1.00 (±0.00) |
| Dodori NR | 0.95 | 0.95 (±0.05) | 0.85 (±0.03) |
| Arabuko-Sokoke Forest | 0.11 | 1.00 (±0.17)* | 0.01 (±0.01) |

* interpret with caution; limited sample data.

**Behaviour**: Camera-trapping showed a mainly diurnal/crepuscular pattern with peaks of activity from 06:00 to 10:00 and 16:00 to 19:00. Activity decreased between 11:00 and 16:00, the hottest part of the day. Night time observations occurred, but at a very low rate (Figure 5).

**Figure 5** Temporal distribution of Aders' duiker records in (a) the Boni-Dodori forest system and (b) the Arabuko-Sokoke forest through the 24 hour cycle.



## Summary

Prior to the discovery of Aders' duiker in the Boni-Dodori forest system[1] this Critically Endangered species was known to occur only in the Arabuko-Sokoke forest and in five fragmented and diminishing forest patches on the island of Unguja, Zanzibar, together covering less than 500 km$^2$. The Arabuko-Sokoke forest on the Kenya mainland covers an area of 416 km$^2$, over half (235 km$^2$) of which has been considered the Aders' duiker's preferred *Cynometra* habitat.

An attempt to establish a new population on Chumbe Island (0.3 km$^2$) in the Zanzibar Archipelago was started in 2000. Six animals were translocated but follow up surveys have not detected any population increase. Aders' duiker is considered extremely rare with a decreasing population trend in all the areas it occurs (Finnie 2002; IUCN 2015).

In the Boni-Dodori forest system, occupancy was estimated at 95-100% and events occurred in almost every fully operational camera site. Trapping rates were 2-3 orders of magnitude greater than in the Arabuko-Sokoke forest, despite the fact that the Arabuko-Sokoke camera grid was deliberately located within the Aders' duiker's favoured habitat (Cynometra thicket). The study confirms the range extension and also indicates the population is isolated from the previously known range and to the north of Kenya's two largest rivers, the Galana-Sabaki and Tana.

The very high levels of occupancy in the camera-trap grids in the Boni–Dodori forest system, very close to or at 100 %, suggest that this species is consistently distributed through this habitat. The potential forest and thicket area measured from the classified map (Figure 6) is at least 3,000 km$^2$. This more than triples the combined previously known range of Aders' duiker (Finnie 2002). The survey has shown that the Boni-Dodori forest system comprises the most important known global population centre for this Critically Endangered antelope.

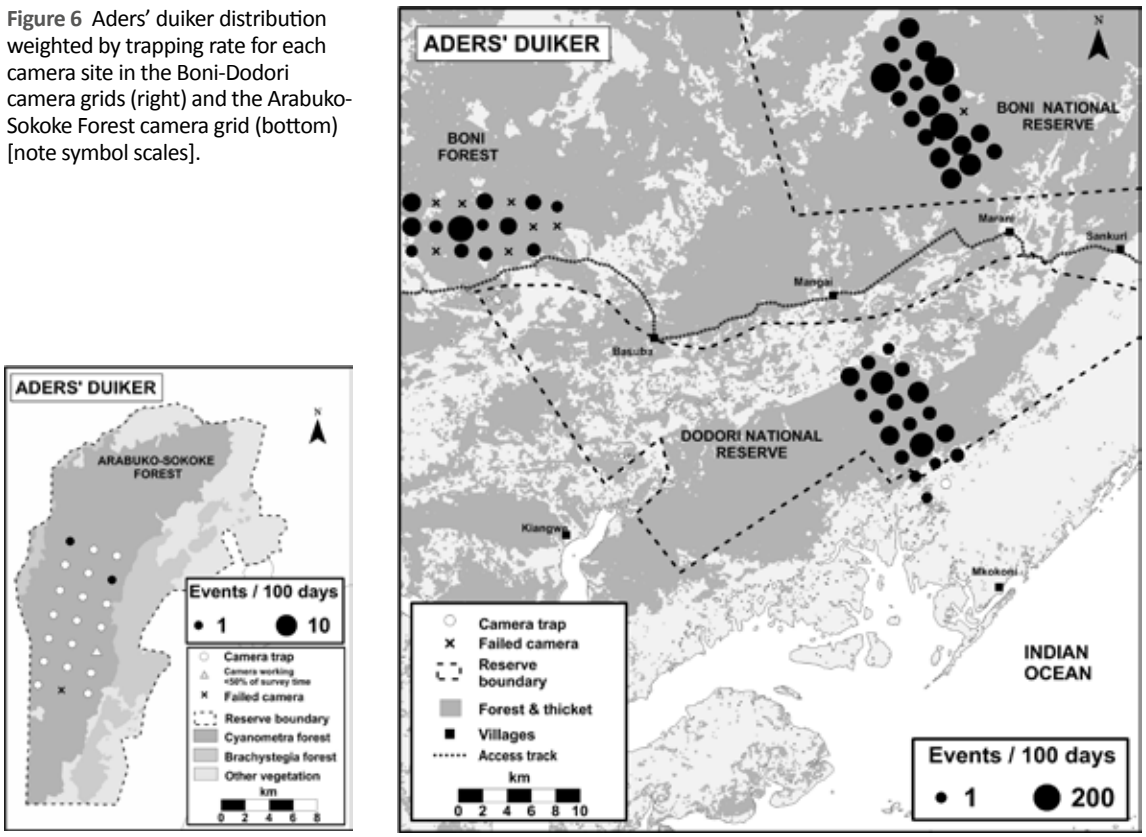



**Figure 6** Aders' duiker distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

1 First noted in an unpublished report to Garissa county council (Gwynne and Smith 1974)

## *2 Cephalophus harveyi*
(Thomas, 1893)

**Common names**
Harvey's duiker (English).

**Species description**
Harvey's Duiker is average sized for the taxon, so larger than Aders' duiker. In daylight they are recognised by their rich red colouring, the black forehead and line down the centre of the face and nape and by their dark legs. They completely lack the bright white rump band of Aders' duiker. In infrared illuminated camera-trap images they appear relatively uniform, usually with obvious darkening on the otherwise unpatterned legs. The images obtained in this study also show variation in the presence and/or degree of development of the dark face stripe. The tail is narrow (without white as in Aders' duiker) and unlike the bushier tails of blue duiker and suni.

**Global conservation status**
IUCN Red List Status: Least Concern.

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: First Schedule.
African Convention on the Conservation of Nature and Natural Resources: Not Listed.

***Camera-trap survey results***

**Relative abundance:** Harvey's duiker was the second most frequently recorded duiker species and the fourth most frequently recorded species of large herbivore found by the study. The highest trapping rates were in the Boni camera grids with much lower trapping rates recorded in the Dodori and Arabuko-Sokoke Forest camera grids (Table 7).

**Table 7 Harvey's duiker trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.**

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 76 | 1670 | 4.60 (±0.51) |
| Boni forest | 13 | 1026 | 1.30 (±0.36) |
| Dodori NR | 3 | 1087 | 0.26 (±0.15) |
| Arabuko-Sokoke Forest | 7 | 2049 | 0.35 (±0.13) |

**Occupancy**: In the Boni camera grids events occurred at >74% of fully operational camera sites compared to ca. 15% of sites in Dodori. These occupancy estimates suggest Harvey's duikers occur inland more frequently than near the coast. Although Harvey's duiker were recorded at 26% of camera sites in the Arabuko-Sokoke Forest grid, the uneven frequency of these observations prevented calculation of an estimated occupancy (Table 8).

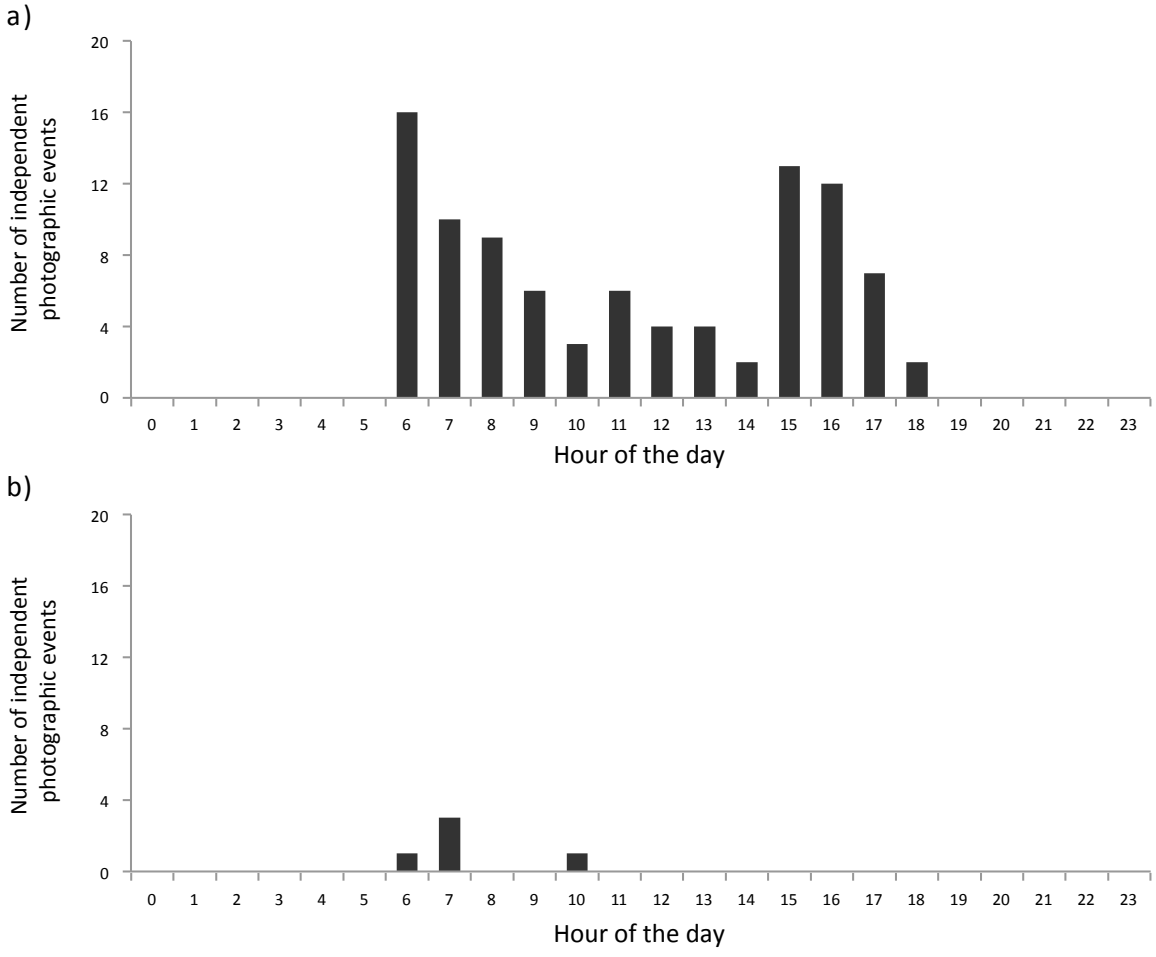
**Table 8** Naïve occupancy and modelled occupancy and detection probability estimates for the Harvey's duiker in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.63 | 0.64 (±0.11) | 0.42 (±0.05) |
| Boni forest | 0.46 | 0.63 (±0.23) | 0.17 (±0.07) |
| Dodori NR | 0.10 | 0.17 (±0.16)* | 0,15 (±0.13) |
| Arabuko-Sokoke Forest | 0.32 | 0.99 (±0.27)* | 0.03 (±0.02) |

* interpret with caution; limited sample data.

**Behaviour**: The camera-trap data shows a mainly diurnal/crepuscular pattern for Harvey's duiker, with peaks of activity from 05:00 to 09:00 and 15:00 to 18:00, decreased activity during the middle of the day and no records at night (Figure 7).

**Figure 7** Temporal distribution of Harvey's duiker records in (a) the Boni-Dodori forest system and (b) the Arabuko-Sokoke Forest through the 24 hour cycle.



## Summary

The Boni-Dodori and Arabuko-Sokoke Forest study areas lie within the known range of Harvey's duiker (IUCN 2015) but the study has shown that, just as for other small forest antelopes, this species is recorded more frequently in the Boni-Dodori forest system than in the Cynometra habitat of Arabuko-Sokoke Forest (Figure 8). These results can be compared with camera-trapping studies conducted in the Udzungwa Mountain Forests, Tanzania, where rates ranging from 0.112-0.291 events / 100 days were obtained in one region and from 2.8-28.9 in another (Rovero and Marshall 2009). It is noted by the IUCN SSC Antelope Specialist Group that although Harvey's duiker are classed as least concern, numbers are believed to be declining and their protection will depend on maintaining populations in areas less affected by habitat destruction and illegal hunting.

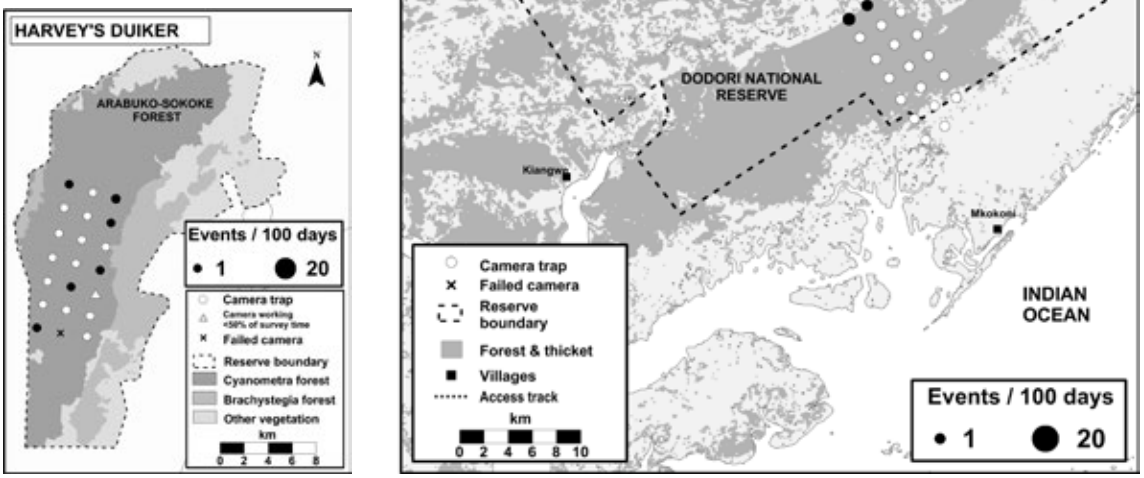



**Figure 8** Harvey's duiker distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

## 3 *Philantomba monticola*

(Thunberg, 1789)

**Common names**
Blue duiker (English).

**Species description**
The blue duiker is a small grey-brown antelope with a very large continental distribution. There is considerable debate as to the number of forms which should be recognised. Identification in camera-trap images, especially black and white infra-red images, depends on a combination of body shape and head features, e.g. a characteristically narrow muzzle with dark rimmed, relatively small and round-tipped ears, narrow pale eyebrow lines in some adults and evidence of vertical rather than horizontal tail flicking. It can be easily confused with Suni in infra-red images if these structural details are not clear.

**Global conservation status**
IUCN Red List Status: Least Concern.

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: First Schedule.
African Convention on the Conservation of Nature and Natural Resources: Not Listed.

***Camera-trap survey results***

**Relative abundance:** Blue duiker was the least frequently recorded duiker species, ranking ninth among the seventeen species of large herbivores recorded. The species was recorded in the Arabuko-Sokoke Forest camera grid with a low encounter rate (30 events) where it was the second most frequently recorded forest antelope after the suni. Although blue duiker were detected in the Boni-Dodori forest system during a small scale pilot study in 2008 (Andanje et al. 2011b), only two further records were obtained during the much larger sample effort at Boni-Dodori in this study (Table 9).

**Table 9** Blue duiker trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 3 | 1670 | 0.18 (±0.11) |
| Boni forest | 0 | 1026 | - |
| Dodori NR | 9 | 1087 | 0.79 (±1.84) |
| Arabuko-Sokoke Forest | 30 | 2049 | 1.47 (±0.25) |

**Occupancy**: Blue duikers were recorded at 11 of 18 camera-trap sites in Arabuko-Sokoke Forest, giving Naïve occupancy of 16% and indicating the species is well distributed throughout the forest. The number of events was insufficient to model occupancy and detection probability (Table 10).

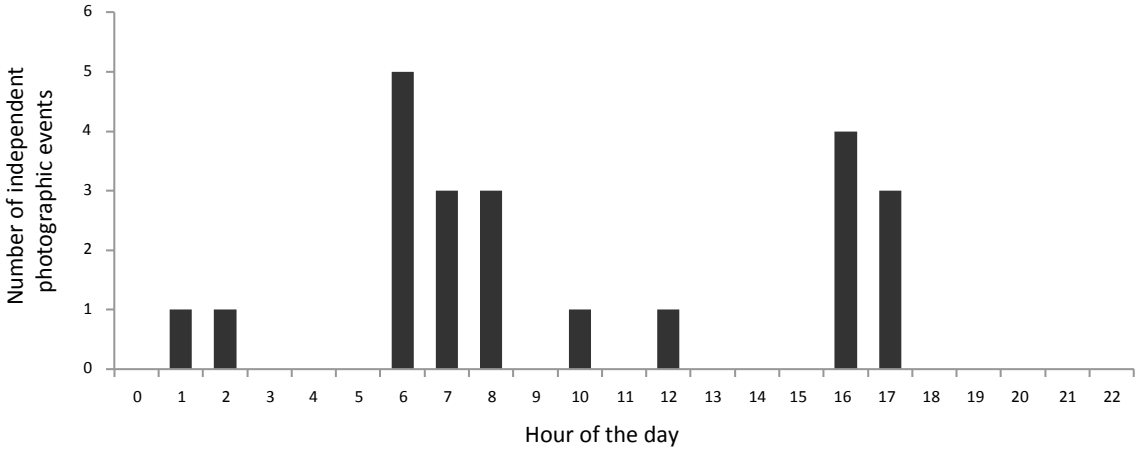
**Table 10** Naïve occupancy and modelled occupancy and detection probability estimates for the blue duiker in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.05 | 0.05 (±0.0)* | 0.32 (±0.17) |
| Boni forest | - | - | - |
| Dodori NR | 0.25 | 0.41 (±0.23)* | 0.16 (±0.10) |
| Arabuko-Sokoke Forest | 0.53 | 0.60 (±0.14) | 0.19 (±0.05) |

* interpret with caution; limited sample data.

**Behaviour**: The distribution of recorded events indicates a crepuscular activity pattern with a small number of events occurring in the middle of the day and night. This species normally rests at night but in heavily disturbed areas they may become more active at night (Kingdon 1997). The majority of the 30 events which occurred in Arabuko-Sokoke Forest took place between 06:00 and 18:00 with marked crepuscular peaks at sunrise and sunset (Figure 9).

**Figure 9** Temporal distribution of blue duiker records in the Arabuko-Sokoke forest through the 24 hour cycle.



## Summary

The survey has confirmed the presence of blue duiker north of the Tana River. Although only photographed on two occasions in Boni National Forest (and once near Dodori National Forest in the 2008 pilot study) this represents a range extension of over 200 km compared to published distribution maps (Kingdon 1997; East 1999; IUCN SSC Antelope Specialist Group 2008). The current data suggest that the species is more frequent than either Harvey's or Aders' duiker in the *Cynometra* forest of Arabuko-Sokoke (Figure 10) making it one of the very few species to be recorded more frequently in the southern forest.

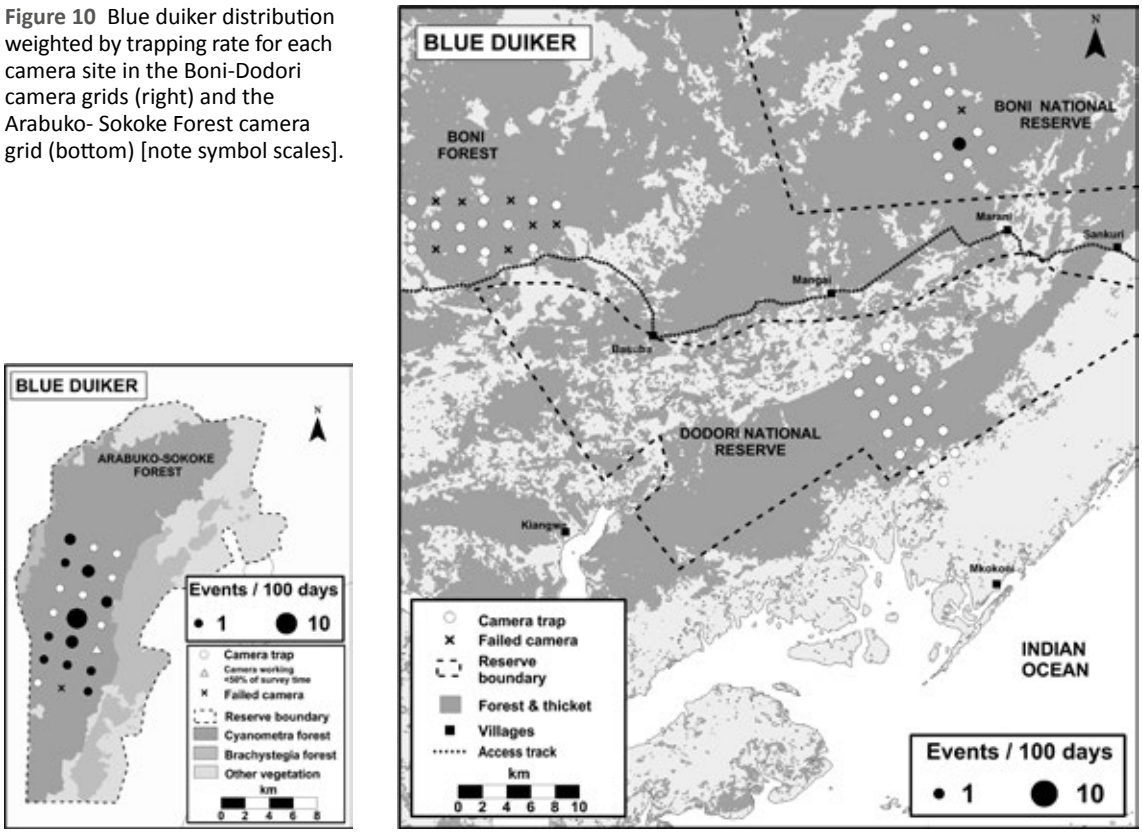



**Figure 10** Blue duiker distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko- Sokoke Forest camera grid (bottom) [note symbol scales].

## 4 *Nesotragus moschatus*
(Von Dueben, 1846)

**Common names**
Suni (English).

**Species description**
The suni is a very small, plain brown antelope with slender legs weighing 4-6 kg (Kingdon, 1997). They are relatively uniform and unpatterned on the body. Sunis frequently move in pairs, sometimes with an accompanying calf. The ears are subtly larger and unmarked compared to the rounder and dark-margined ears of the blue duiker. The wide-set, narrow horns of the males lack a central tuft of hair, a useful feature in distinguishing them from all duikers. In cases where poor infrared illumination or only partial views of the body are available the tail may still help identification, being bushier than on the two Cephalophus duikers and mainly flicked side to side, unlike vertical flicking of Blue duiker.

**Global conservation status**
IUCN Red List Status: Least Concern.

**Legal status**
CITES: Not Listed
Kenya Wildlife (Conservation and Management) Act: First Schedule.
African Convention on the Conservation of Nature and Natural Resources: Class A.

***Camera-trap survey results***

**Relative abundance:** Suni were found in all the surveyed areas and were the second most frequently recorded mammal species after Aders' duiker. In the Boni-Dodori camera grids encounter rates ranged from 37 events / 100 days in the Dodori camera grid to 78 events / 100 days in the Boni forest camera grid. They were the most frequently recorded species in the Arabuko-Sokoke camera grid though at 24 events / 100 days they were still encountered at a lower rate than in the Boni-Dodori camera grids (Table 11).

**Table 11** Suni trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 717 | 1670 | 43.14 (±1.95) |
| Boni forest | 797 | 1026 | 78.32 (±3.64) |
| Dodori NR | 401 | 1087 | 35.34 (±2.25) |
| Arabuko-Sokoke Forest | 488 | 2049 | 24.18 (±1.24) |

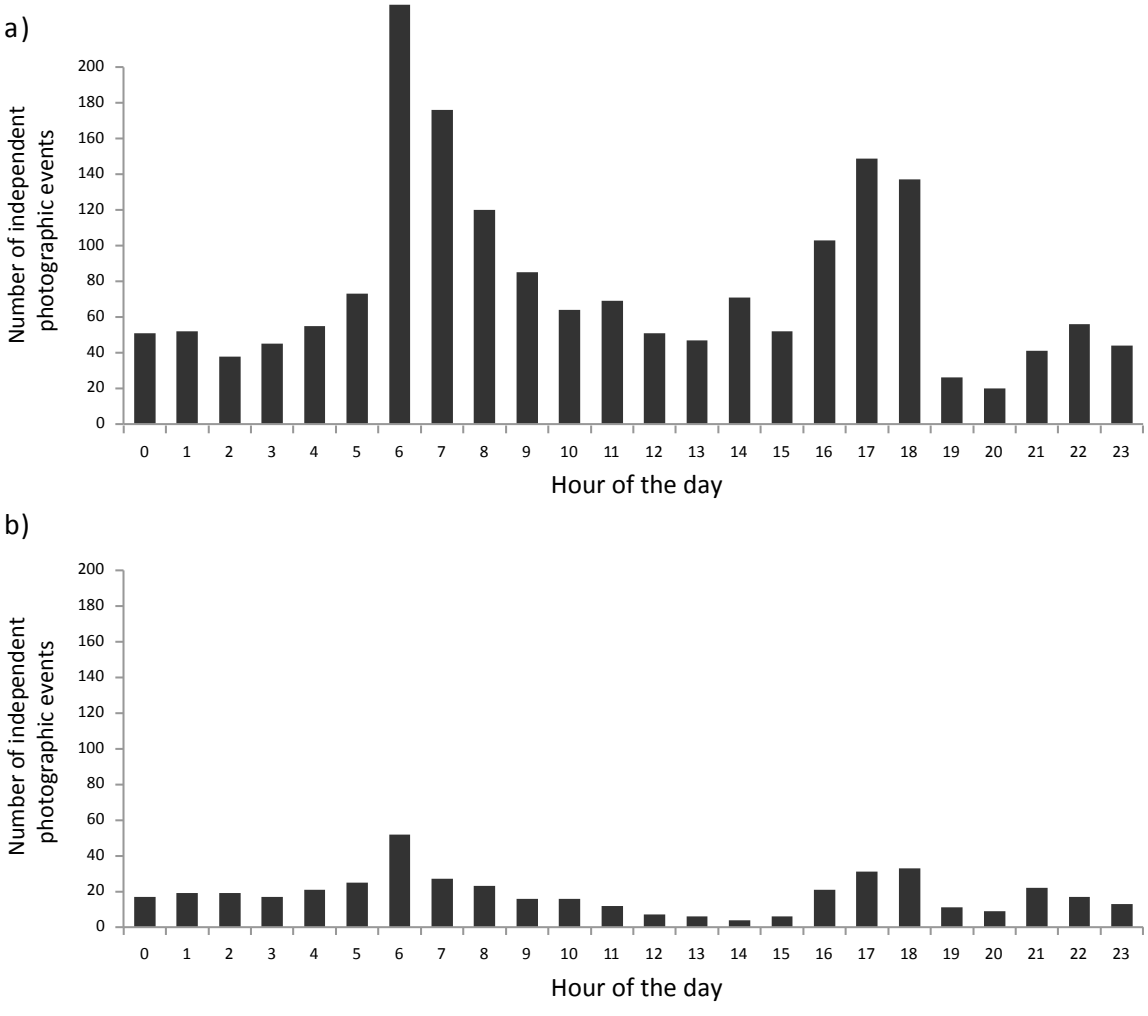
**Occupancy**: Occupancy estimates were high in all four camera grids. Comparison of detection probabilities indicated a lower probability in Arabuko-Sokoke Forest compared to the Boni-Dodori forest system (Table 12).

**Table 12** Naïve occupancy and modelled occupancy and detection probability estimates for the suni in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.95 | 0.95 (±0.05) | 0.82 (±0.03) |
| Boni forest | 1.00 | 1.00 (±0.00) | 1.00 (±0.00) |
| Dodori NR | 1.00 | 1.00 (±0.00) | 1.00 (±0.00) |
| Arabuko-Sokoke Forest | 0.95 | 0.95 (±0.05) | 0.60 (±0.04) |

**Behaviour**: Recorded events indicate this species was active throughout the 24 hour period at all sites but with marked crepuscular peaks around sunrise and sunset. The results show that the activity pattern of suni and Aders' duiker are broadly similar but suni are consistently more active at night. Activity at each of the four camera grids shows that suni tend to be relatively more active at night in the Arabuko-Sokoke Forest camera grid compared to the Boni-Dodori forest system, with the largest difference occurring between Arabuko-Sokoke Forest and Boni forests (Figure 11).

**Figure 11** Temporal distribution of suni records in (a) the Boni-Dodori forest system and (b) the Arabuko-Sokoke Forest through the 24 hour cycle.



## Summary

Suni are one of the most frequently recorded species in all four coastal forest camera grids (Figure 12). Results from the Boni-Dodori forest system confirm a significant range extension north of the Tana River relative to IUCN Red List data (IUCN 2015). Because it is well represented at all four camera grids it is a useful indicator of comparative conditions across the sites. The species is more frequently recorded, with higher detectability estimates, in the Boni-Dodori forest system, and lower detectability appears to be associated with greater tendency to nocturnal activity in the Arabuko-Sokoke Forest camera grid. These differences are consistent with expectations of behaviour in the presence of hunting and other kinds of pressure from humans. Suni are known to be targeted by bushmeat hunters in Arabuko-Sokoke Forest (Lutz and Newiadomsky 2007) and levels of general disturbance (wood cutting, tourist bird watching etc.) are higher in the Arabuko-Sokoke Forest than in the Boni-Dodori forest system.

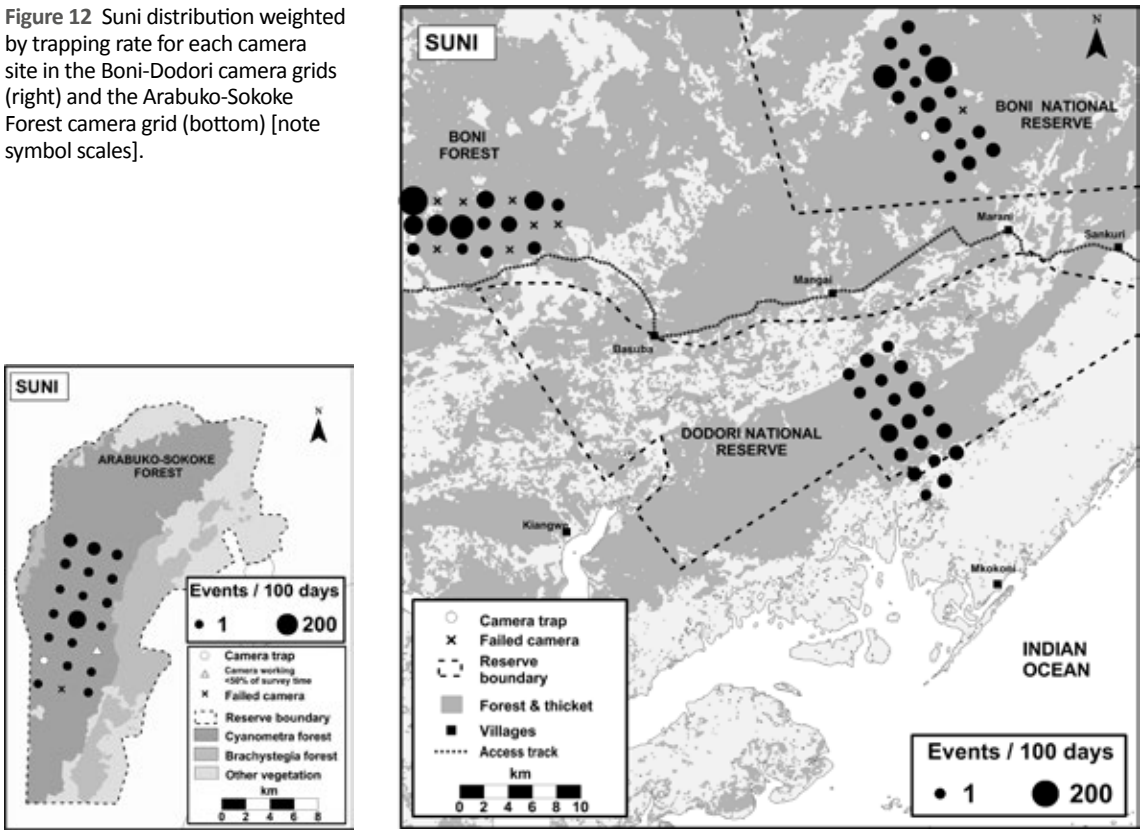



**Figure 12** Suni distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

## 5 *Madoqua kirkii*
(Gunther, 1880)

**Common names**
Kirk's dik-dik (English).

**Species description**
Dik-dik are very small antelope associated with dry scrub, thickets, and *Acacia-Commiphora* woodlands, with a centre of diversity in the horn of Africa. They are recognised by a duiker-like tuft of long hair on the crown, short tails and in southern forms, typically elongated noses. Distribution maps indicate that two species are potentially present in the Boni-Dodori forest system: Guenther's dik-dik (*Madoqua guentheri*) and Kirks' dik-dik (*Madoqua kirkii*). Dik-dik recorded in this study have been provisionally identified as Kirk's dik-dik in the absence of evidence of an exceptionally elongated nose, which is characteristic of Guenther's dik-dik.

**Global conservation status**
IUCN Red List Status: Least Concern.

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: Not Listed.
African Convention on the Conservation of Nature and Natural Resources: Not Listed.

***Camera-trap survey results***

**Relative abundance:** A single pair of Kirk's dik-dik were photographed once at one site at the southernmost margin of the Dodori camera grid (Table 13).

**Table 13** Kirk's dik-dik trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 0 | 1670 | - |
| Boni forest | 0 | 1026 | - |
| Dodori NR | 1 | 1087 | 0.09 (±0.09) |
| Arabuko-Sokoke Forest | 0 | 2049 | - |

**Occupancy**: With only one camera site recording Kirk's dik-dik on the outer limit of the Dodori camera grid, this species is considered only marginally present in the study sample areas (Table 14).

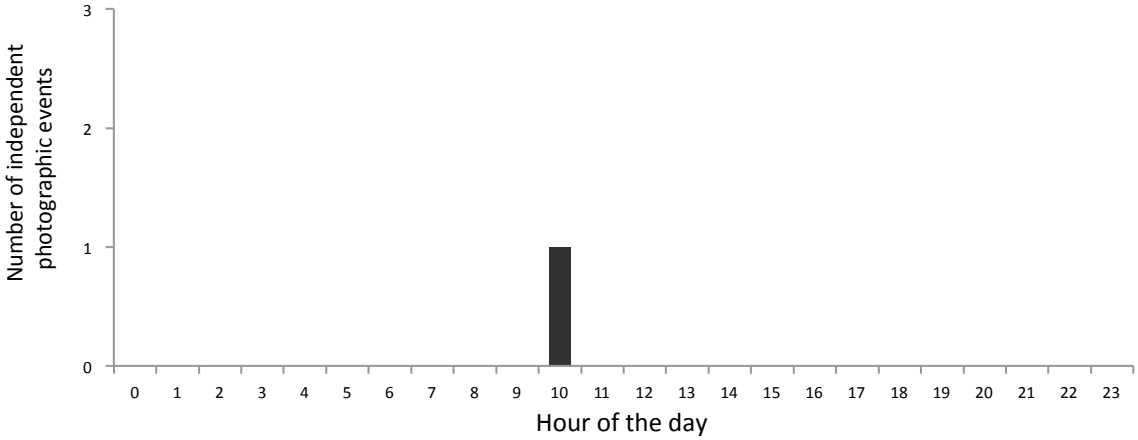
**Table 14** Naïve occupancy and modelled occupancy and detection probability estimates for the Kirk's dik-dik in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | N/A | N/A | N/A |
| Boni forest | N/A | N/A | N/A |
| Dodori NR | 0.05 | 0.05 (±0.00)* | 0.01 (±0.01) |
| Arabuko-Sokoke Forest | N/A | N/A | N/A |

* interpret with caution; limited sample data.

**Behaviour**: The single event was recorded in daylight as would be expected for this diurnal species (Figure 13).

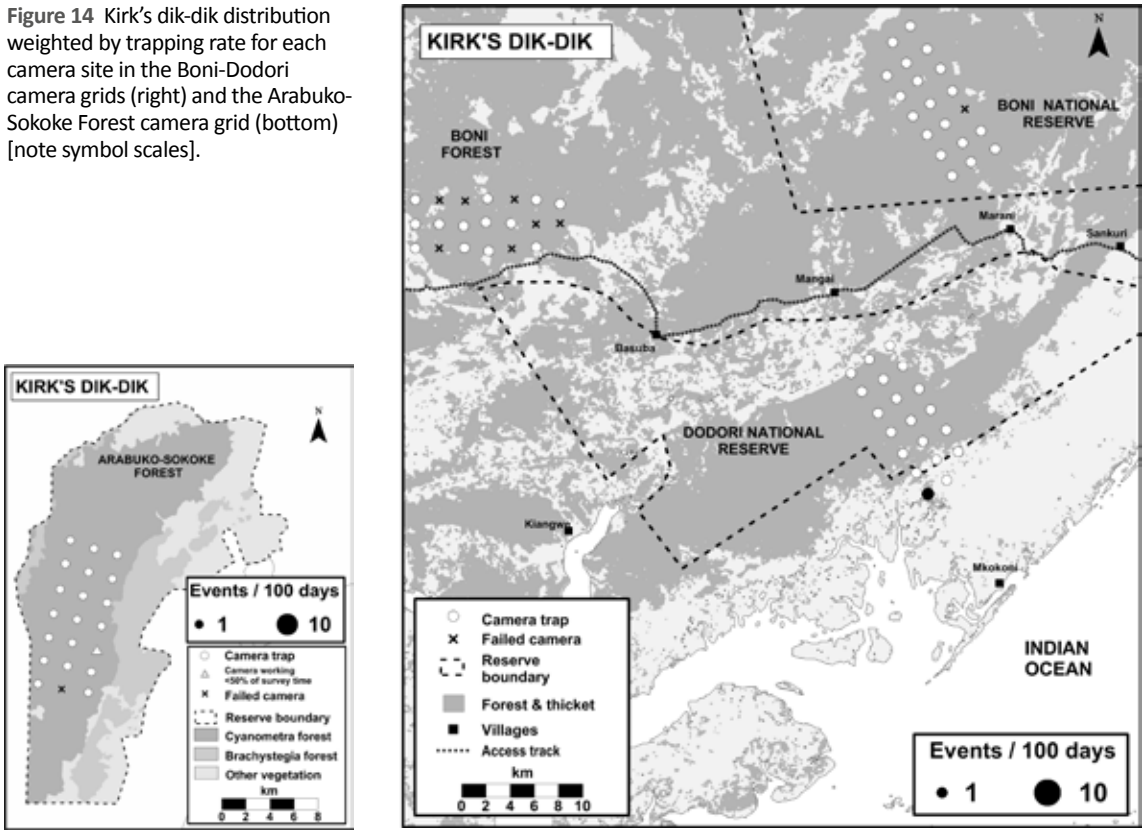
**Figure 13** Temporal distribution of Kirk's dik-dik records in the Boni-Dodori forest system through the 24 hour cycle.



## Summary

The single occurrence of Kirk's dik-dik at the southern margin of the Dodori camera grid aligns them with other savannah species recorded only in this area (Figure 14). They are not representative of the coastal forest community which is the primary target of this study. Nevertheless, their presence between the forest and the coastline is indicative of the mosaic of habitats in this area and contributes to the important diversity of the region.

**Figure 14** Kirk's dik-dik distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].



## 6 *Tragelaphus scriptus*
(Pallas, 1766)

**Common names**
Bushbuck (English).

**Species description**
The bushbuck is a widespread and well-known member of the spiral-horned antelope group. The chestnut coat is typically marked by a combination of vertical white stripes and prominent white flank spots which show well on most black and white infrared images. Even in partial images these markings assist in distinguishing bushbuck from the larger lesser kudu, which generally shows bolder, denser striping and little or no spotting. In males the single open twist of the keeled horns distinguishes from the tight spiral horns of lesser kudu males.

**Global conservation status**
IUCN Red List Status: Least Concern.

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: First Schedule.
African Convention on the Conservation of Nature and Natural Resources: Not Listed.

***Camera-trap survey results***

**Relative abundance:** Bushbuck were recorded in all three camera grids of the Boni-Dodori forest system with the highest trapping rate occurring in Dodori (Table 15). They were the fifth most frequently recorded large herbivore. Bushbuck were recorded only once at Arabuko-Sokoke Forest. In the northern camera grids they were recorded less frequently than most of the truly forest-adapted antelopes of the region, (Aders' duiker, suni and Harvey's duiker), but more frequently than the more woodland/savannah associated antelopes (lesser kudu, dik-dik). This result is expected given the focus on locating camera sites in forest habitat and the preference of bushbuck for habitat edges (IUCN Red List 2015).

**Table 15** Bushbuck trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 19 | 1670 | 1.13 (±0.26) |
| Boni forest | 4 | 1026 | 0.40 (±0.20) |
| Dodori NR | 39 | 1087 | 3.54 (±0.60) |
| Arabuko-Sokoke Forest | 1 | 2049 | 0.05 (±0.05) |

**Occupancy**: Bushbuck were recorded at 60% of the camera-traps in the Dodori forest and 16% at Boni forest (Table 16).

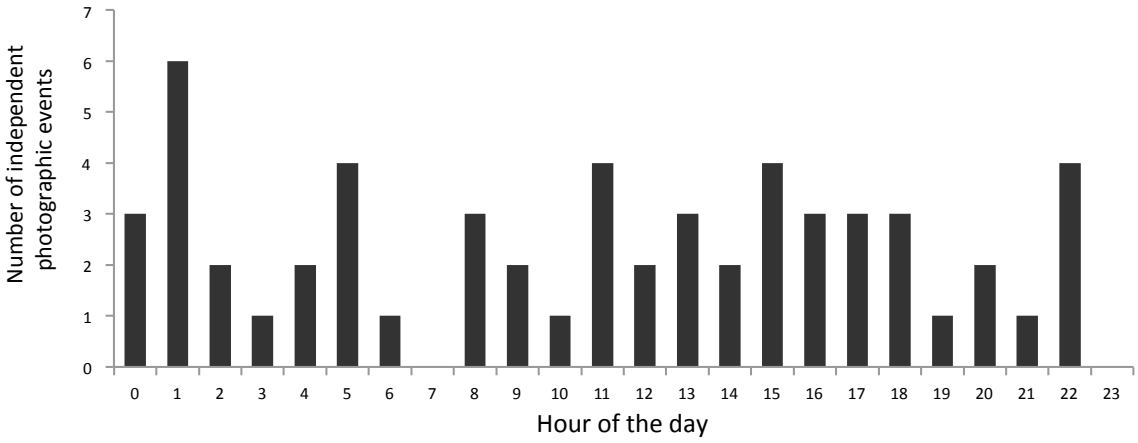
**Table 16** Naïve occupancy and modelled occupancy and detection probability estimates for the bushbuck in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.16 | 0.18 (±0.10) | 0.24 (±0.09) |
| Boni forest | 0.08 | 0.08 (±0.00)* | 0.42 (±0.20) |
| Dodori NR | 0.60 | 0.67 (±0.13) | 0.36 (±0.07) |
| Arabuko-Sokoke Forest | 0.05 | 0.05 (±0.00)* | 0.01 (±0.01) |

* interpret with caution; limited sample data.

**Behaviour**: There is an even distribution of bushbuck events across 24 hours in the Boni-Dodori camera grids. Distribution of events between day and night is almost exactly even with 29 of the 62 events taking place in daylight (Figure 15).

**Figure 15** Temporal distribution of bushbuck records in the Boni-Dodori forest system through the 24 hour cycle.



## Summary

Bushbuck are sometimes thought of as habitat edge or mixed habitat specialists, known to associate with thick cover but avoiding closed canopy (Kingdon, 1987; IUCN 2015). In this study bushbuck were detected at a frequency intermediate between the forest adapted and woodland/savannah adapted antelopes, which supports this interpretation. Bushbuck were most frequently recorded in Dodori (Figure 16), the only site where woodland/savannah adapted species such as lesser kudu and dik-dik were also detected. The presence of these species also suggests that the Dodori forest camera grid has a greater diversity of habitats than the other camera grids. The paucity of records at Arabuko-Sokoke Forest may be explained by the deliberate placement of camera sites in areas of uniform *Cynometra* forest, where there is a thick and extensive canopy. Bushbuck are believed to be comparatively resilient to human modifications of their habitat and consequently are not thought to be currently dependent on protected areas alone (IUCN 2015).

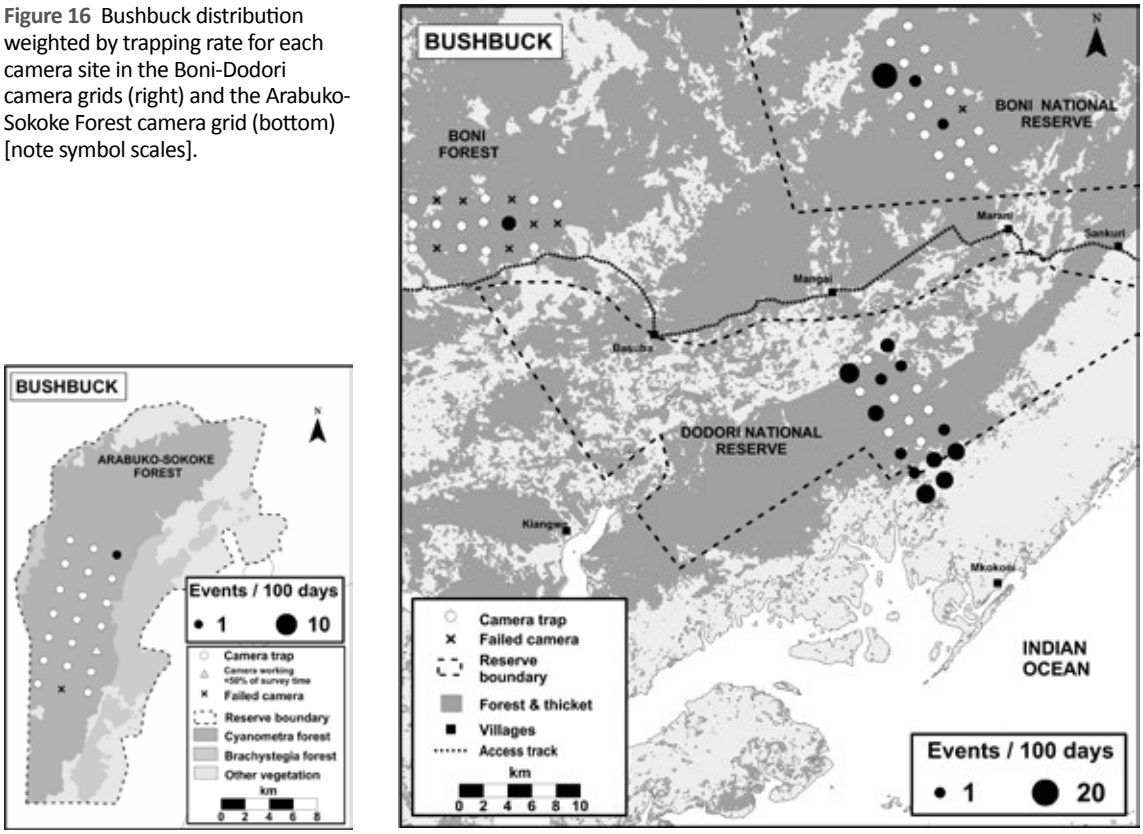



**Figure 16** Bushbuck distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

## *7 Tragelaphus imberbis*
(Blyth, 1869)

**Common names**
Lesser kudu (English).

**Species description**
Recognisable in black and white camera-trap images by body size, strong vertical white stripes running the full length and height of the flanks and lacking the spotting on the lower flank seen in bushbuck. Lesser kudu females are red-brown and hornless while adult males are grey and carry characteristic tightly spiralled horns.

**Global conservation status**
IUCN Red List Status: Near Threatened.

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: First Schedule.
African Convention on the Conservation of Nature and Natural Resources: Class B.

***Camera-trap survey results***

**Relative abundance:** Lesser kudu were recorded in four separate events at two camera sites on the southern margin of the Dodori camera grid. Like dik-dik, this species is more associated with *Acacia-Commiphora* woodland habitat and finding lesser kudu at the same location as dik-dik and waterbuck reinforces the impression that the southernmost camera sites in the Dodori camera grid were sampling species associated with habitat outside the core coastal forest (Table 17).

**Table 17** Lesser kudu trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 0 | 1670 | - |
| Boni forest | 0 | 1026 | - |
| Dodori NR | 4 | 1087 | 0.35 (±0.17) |
| Arabuko-Sokoke Forest | 0 | 2049 | - |

**Occupancy**: With only two adjacent camera sites recording lesser kudu, both on the southern limit of the Dodori camera grid, this species is considered only marginally present in the study sample areas (Table 18).

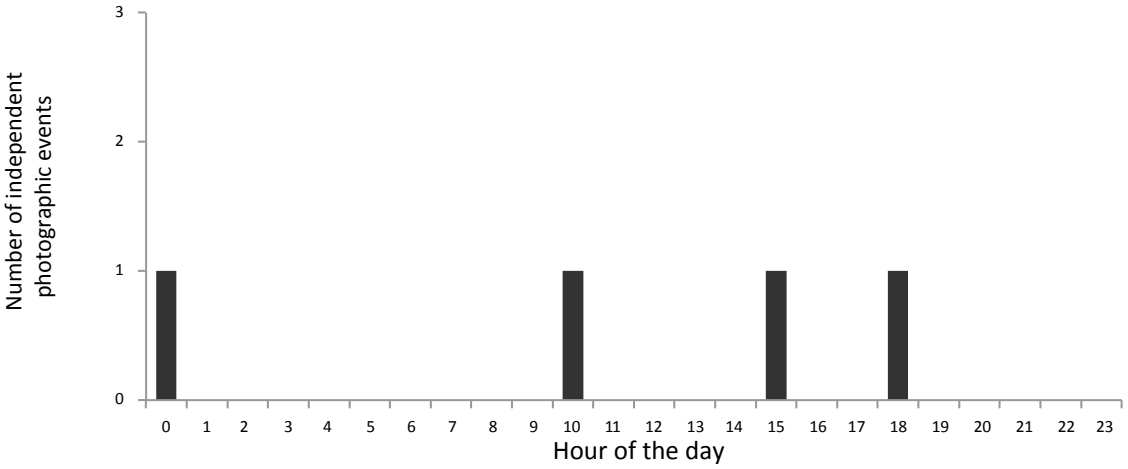
**Table 18** Naïve occupancy and modelled occupancy and detection probability estimates for the lesser kudu in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | N/A | N/A | N/A |
| Boni forest | N/A | N/A | N/A |
| Dodori NR | 0.10 | 0.14 (±0.11)* | 0.21 (±0.17) |
| Arabuko-Sokoke Forest | N/A | N/A | N/A |

* interpret with caution; limited sample data.

**Behaviour**: There are too few events to draw any firm conclusions about the activity pattern of lesser kudu in the study areas. Two of the four events occurred during the day, one at dusk and one during the night (Figure 17).

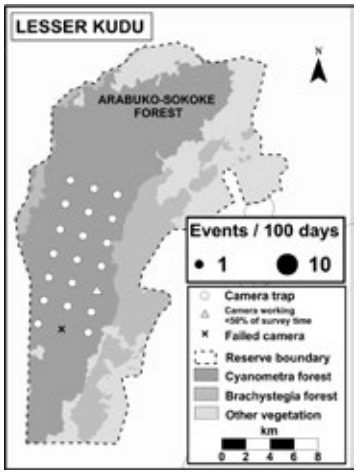
**Figure 17** Temporal distribution of lesser kudu records in the Boni-Dodori forest system through the 24 hour cycle.

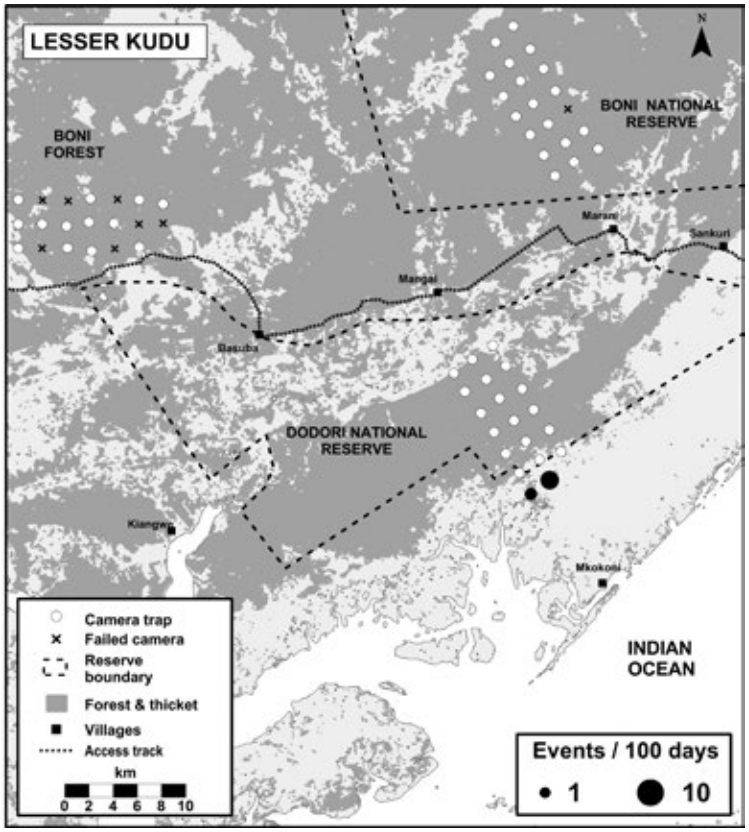


## Summary

The presence of lesser kudu in the Boni-Dodori forest system, albeit only at the southern margin of the Dodori forest, emphasises the diversity of the area. They are not considered representative of the coastal forest community which is the primary target of this study. Nevertheless their presence between the forest and the coastline is indicative of the mosaic of habitats in this area, and contributes to the important diversity of the region (Figure 18).

**Figure 18** Lesser kudu distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].



# 8 *Kobus ellipsiprymnus*
(Ogilbyi, 1833)

**Common names**
Waterbuck (English).

**Species description**
The Waterbuck is a large, shaggy-haired antelope with a characteristic stocky appearance and straight-profiled muzzle. Body colour varies from grey-brown to reddish-brown. The nominate subspecies found in coastal Kenya is distinguished by semi-circular white stripes forming an oval target on the rear quarters.

**Global conservation status**
IUCN Red List Status: Least Concern.

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: First Schedule.
African Convention on the Conservation of Nature and Natural Resources: Class B.

***Camera-trap survey results***

**Relative abundance:** Waterbuck were photographed only once in the Dodori camera grid at one of the same camera sites that recorded woodland/savannah species such as lesser kudu and Kirk's dik-dik. This reinforces the probability that cameras in this zone were sampling species not associated with the interior of the coastal forest (Table 19).

**Table 19** Waterbuck trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 0 | 1670 | - |
| Boni forest | 0 | 1026 | - |
| Dodori NR | 1 | 1087 | 0.09 (±0.09) |
| Arabuko-Sokoke Forest | 0 | 2049 | - |

**Occupancy**: With only one camera station recording waterbuck on the outer limit of the Dodori camera grid, this species is considered only marginally present in the forest areas (Table 20).

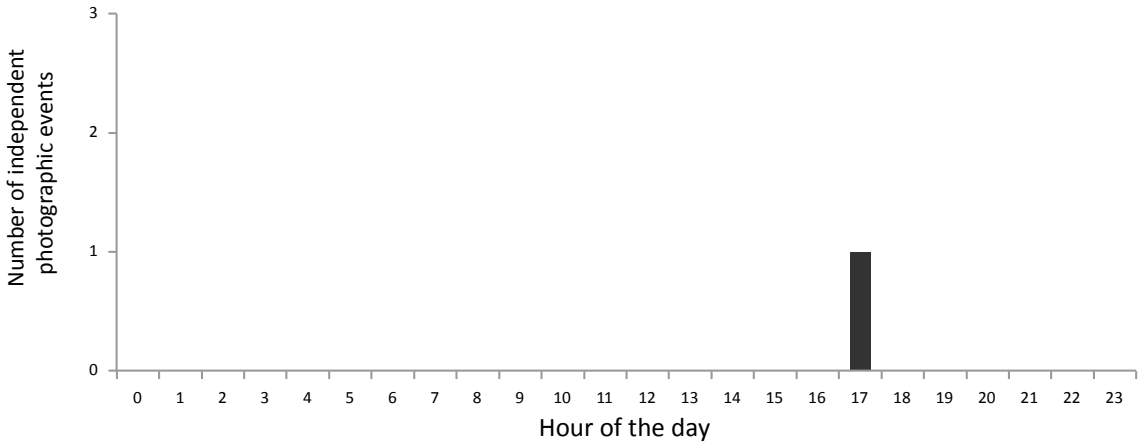
**Table 20** Naïve occupancy and modelled occupancy and detection probability estimates for the waterbuck in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | N/A | N/A | N/A |
| Boni forest | N/A | N/A | N/A |
| Dodori NR | 0.05 | 0.05 (±0.00)* | 0.01 (±0.01) |
| Arabuko-Sokoke Forest | N/A | N/A | N/A |

* interpret with caution; limited sample data.

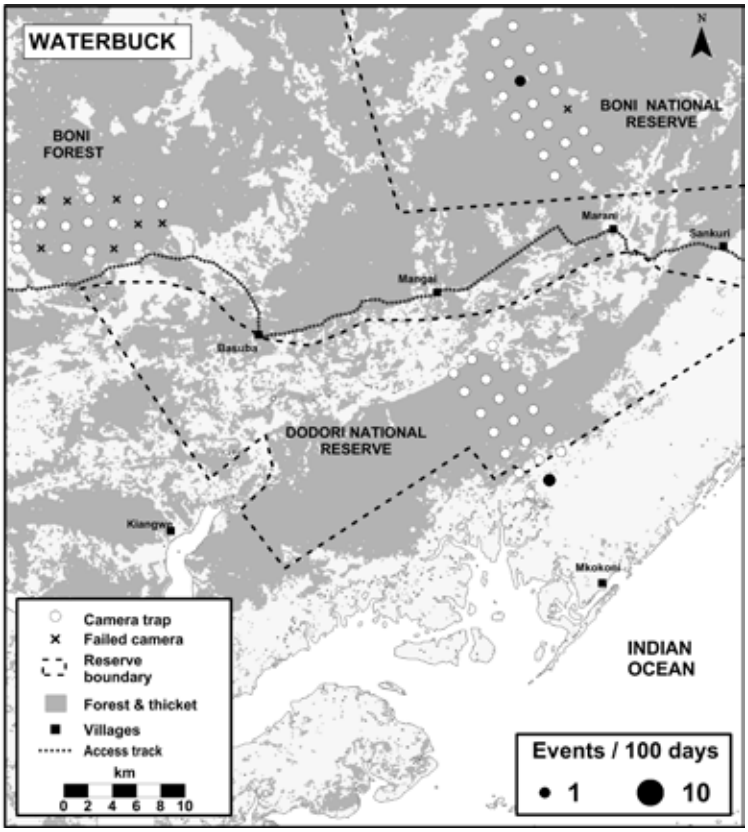
**Behaviour**: The images from the single event occurred in daylight (Figure 19).

**Figure 19** Temporal distribution of waterbuck records in the Boni-Dodori forest system through the 24 hour cycle.



## Summary

Waterbuck were only recorded once in the Boni-Dodori forest system in association with other savannah species at the southern margin of the Dodori camera grid (Figure 20). They are not considered representative of the coastal forest community which is the primary target of this study. Nevertheless their presence between the forest and the coastline is indicative of the mosaic of habitats in this area, and contributes to the important diversity of the region.



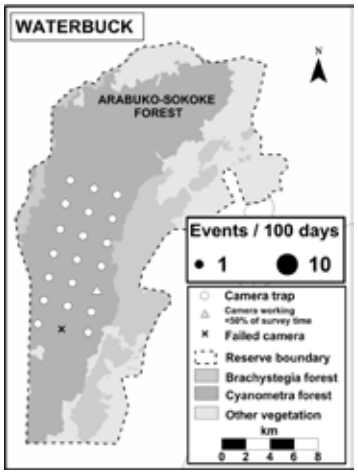




**Figure 20** Waterbuck distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

# 9 *Syncerus caffer*
(Sparrman, 1779)

**Common names**
African buffalo (English); Nyati (Swahili).

**Species description**
The African buffalo is the largest bovid in Africa. Normally unmistakeable, in camera-trap images, partial views of small parts of the whole occur and must be distinguished from cattle. The massive limbs and characteristically sparse strands of dark body hair overlying the grey skin are usually diagnostic. Because they often travel in large groups long sequences of photographs are not unusual and occur in this data set.

**Global conservation status**
IUCN Red List Status: Least Concern.

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: First Schedule.
African Convention on the Conservation of Nature and Natural Resources: Class B.

***Camera-trap survey results***

**Relative abundance:** Buffalo accounted for 129 events in the Boni-Dodori system and was the third most frequently recorded large herbivore, but none were recorded in the Arabuko-Sokoke Forest camera grid. Trapping rates were notably higher in the Boni forest camera grid than in the Boni and Dodori NR camera grids (Table 21). In several cases images scored as a single 'event' comprised the passage of a large breeding herd. Single events involving the passage of more than 100 individuals occurred at two camera stations. These figures represent minimum estimates for herd sizes. Examples of single mature bulls and small bachelor groups were also recorded. These results indicate that, in terms of biomass, buffalo are probably the dominant wild herbivores in the study area.

**Table 21** African buffalo trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 19 | 1670 | 1.16 (±0.28) |
| Boni forest | 95 | 1026 | 9.49 (±1.07) |
| Dodori NR | 15 | 1087 | 1.34 (±0.37) |
| Arabuko-Sokoke Forest | 0 | 2049 | - |

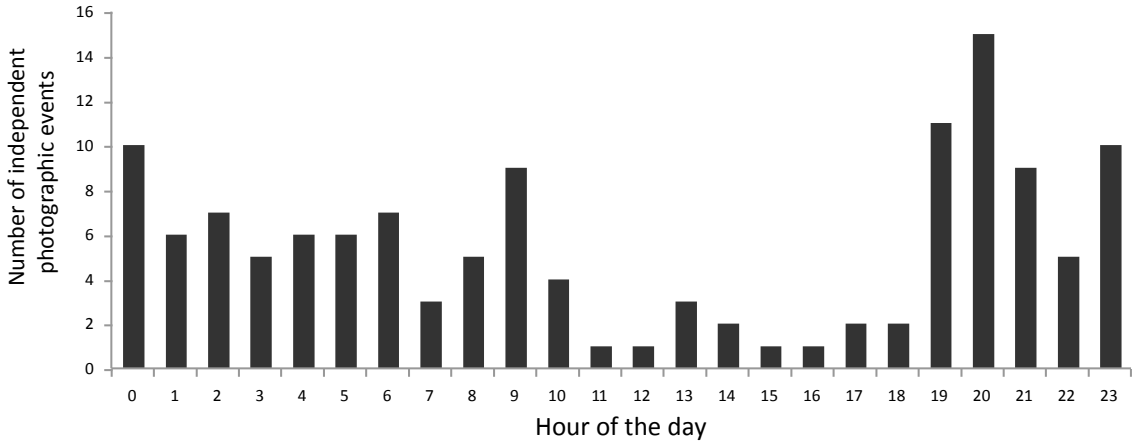
**Occupancy**: Buffalo were recorded at between 15-38% of camera-traps in the Boni-Dodori camera grids (Table 22).

**Table 22** Naïve occupancy and modelled occupancy and detection probability estimates for the African buffalo in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.11 | 0.11 (±0.07) | 0.41 (±0.12) |
| Boni forest | 0.39 | 0.39 (±0.14) | 0.50 (±0.09) |
| Dodori NR | 0.30 | 0.43 (±0.19) | 0.20 (±0.09) |
| Arabuko-Sokoke Forest | N/A | N/A | N/A |

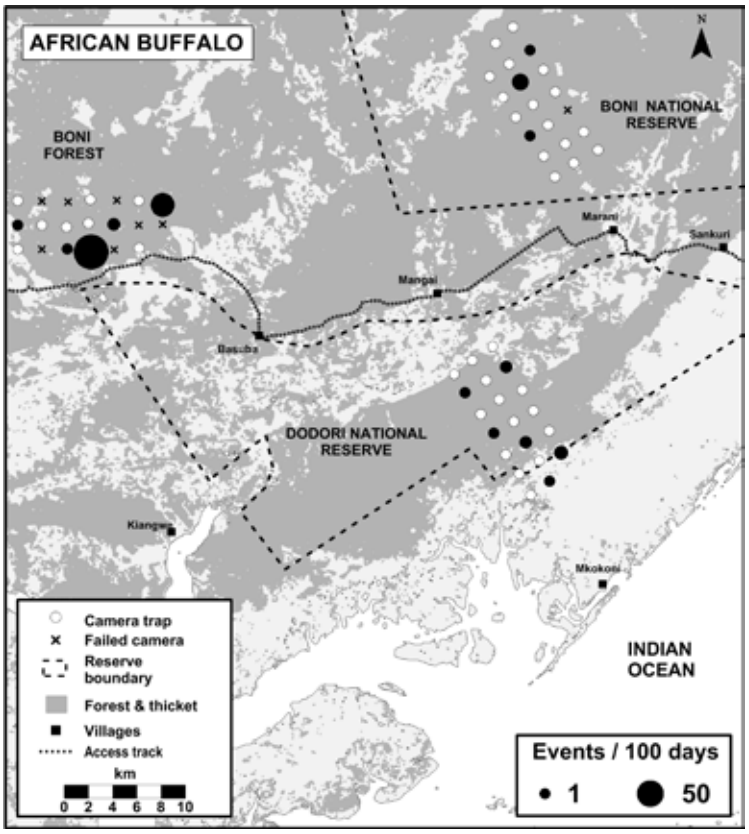
**Behaviour**: Buffalo events were recorded at all hours of the day (Figure 21). Rates were higher through the night and lowest through the hottest hours of the day. African buffalo are believed to be sensitive to disturbance, switching from continuous grazing in quiet areas to dawn, dusk and night-time grazing (Kingdon 1997). It is evident that a low level of day time movement is maintained in these Boni-Dodori camera grids.

**Figure 21** Temporal distribution of African buffalo records in the Boni-Dodori forest system through the 24 hour cycle.



## Summary

African buffalo are well represented in the camera grids of the Boni-Dodori forest system (Figure 22). Evidence of at least one very large breeding herd (taking more than 30 minutes for an unknown proportion of its members to file past the camera) and a number of smaller groups and bachelor males was obtained. The absence of buffalo records in the Arabuko-Sokoke Forest camera grid suggests that they were not present in large numbers in the area. It is not clear whether this result is an indicator of relatively low buffalo numbers, reflects avoidance of the *Cynometra* forest habitat or is a combination of the two.



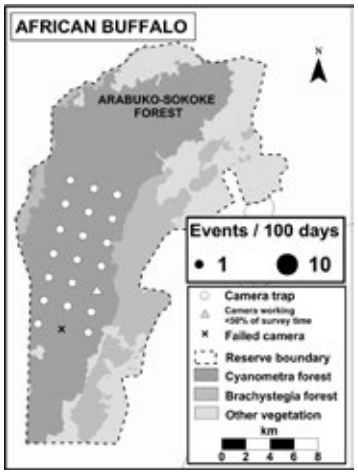




**Figure 22** African buffalo distribution weighted by trapping rate for each camera site in the Boni-Dodori sampling grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

## 10 *Potamochoerus larvatus*
(Cuvier, 1822)

**Common names**
Bushpig (English).

**Species description**
Distinguished in camera-trap pictures from warthogs by a proportionately narrower, longer head, lacking comparably prominent 'warts', shorter tusks, larger ears and evenly distributed, denser hair on the deeper more, slab sided body.

**Global conservation status**
IUCN Red List: Least Concern.

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: Not Listed.
African Convention on the Conservation of Nature and Natural Resources: Not Listed.

***Camera-trap survey results***

**Relative abundance:** Bushpig were the most frequently recorded suid and the only one found in all four camera grids (Table 23).

**Table 23** Bushpig trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 14 | 1670 | 0.84 (±0.23) |
| Boni forest | 9 | 1026 | 0.90 (±0.38) |
| Dodori NR | 7 | 1087 | 0.67 (±0.25) |
| Arabuko-Sokoke Forest | 3 | 2049 | 0.15 (±0.08) |

**Occupancy**: Bushpig encounter rates were range from 30-58% in the Boni-Dodori forest system camera grids. In Arabuko-Sokoke Forest, they were recorded at 16% of camera sites (Table 24).

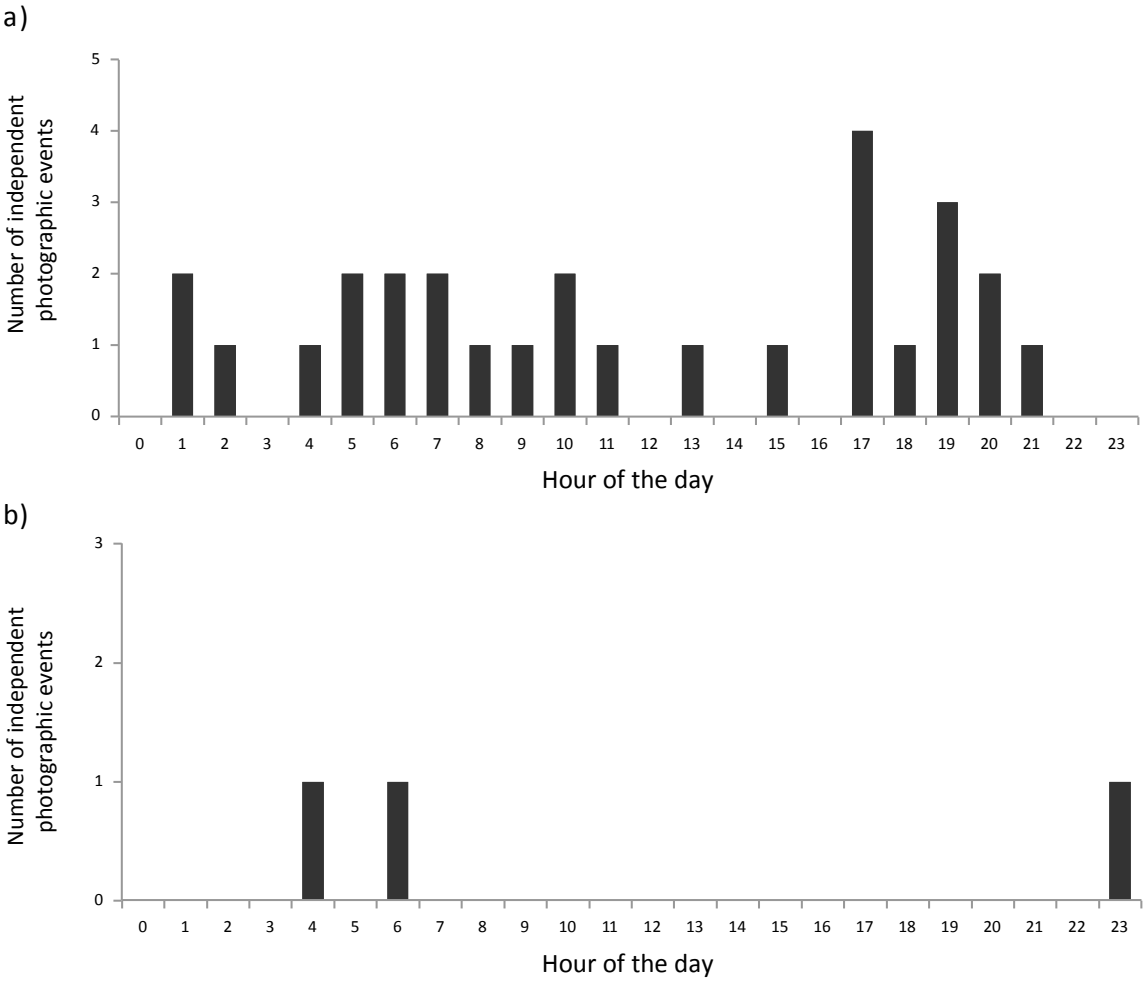
**Table 24** Naïve occupancy and modelled occupancy and detection probability estimates for the bushpig in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.58 | 1.00(±0.01)* | 0.08(±0.02) |
| Boni forest | 0.31 | 0.47 (±0.26)* | 0.14 (±0.08) |
| Dodori NR | 0.30 | 1.00 (±0.02)* | 0.06 (±0.02) |
| Arabuko-Sokoke Forest | 0.16 | 1.00 (±0.13)* | 0.02 (±0.01) |

* interpret with caution; limited sample data.

**Behaviour**: Bushpig were active throughout the day and night and particularly at dusk (17:00-20:00) (Figure 23).

**Figure 23** Temporal distribution of bushpig records in (a) the Boni-Dodori forest system and (b) the Arabuko-Sokoke forest through the 24 hour cycle.



## Summary

Bushpig were consistently present in all four camera grids but like many other large mammal species, they were more frequently recorded in the Boni-Dodori forest system camera grids than at Arabuko-Sokoke Forest (Figure 24). It is particularly notable that bushpig were found in the same camera grid (Boni forest) as the two forms of warthog, although warthog were recorded far less frequently. Sympatry between the two warthogs has been noted previously (de Jong et al. 2009) but the simultaneous presence of three suids is unusual. The ecological relationships between these species in the region merits further investigation, being of theoretical interest in its own right, and also indicating a potential avenue for deeper understanding of ecological diversity in these habitats.

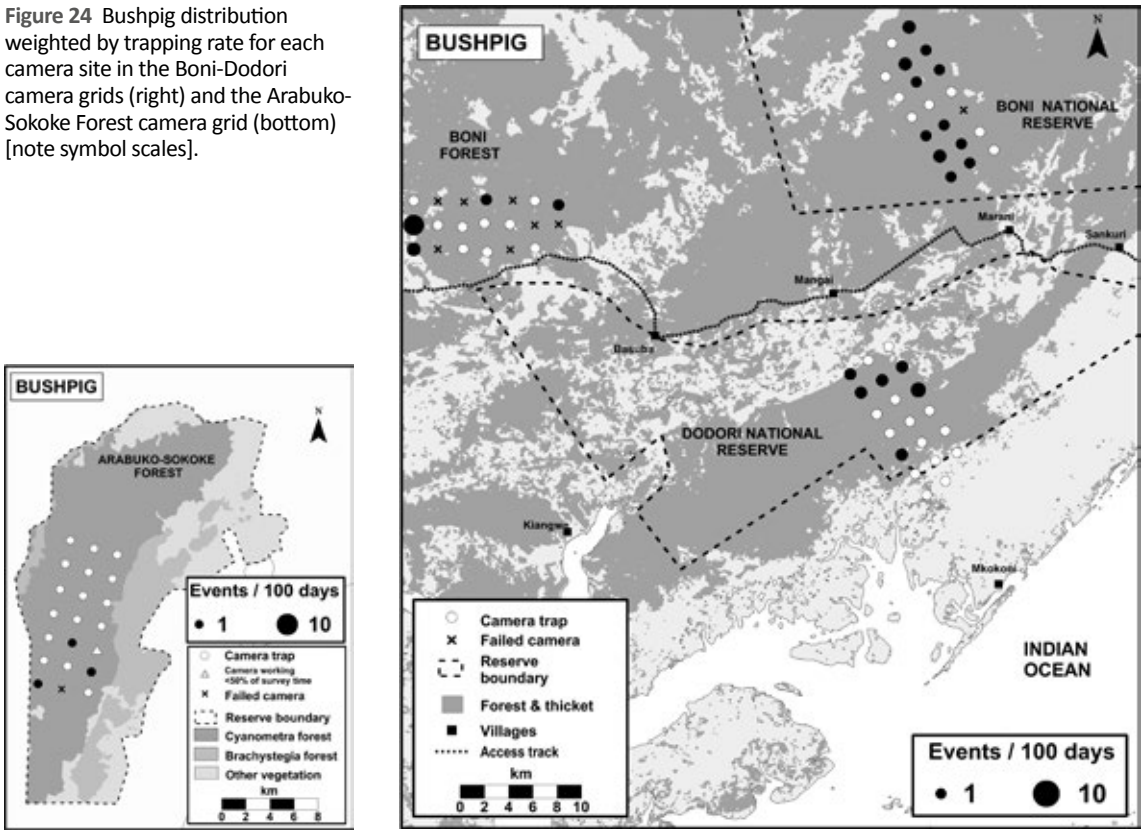



**Figure 24** Bushpig distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

## 11 *Phacochoerus africanus*
(Gmelin, 1788)

**Common names**
Common warthog (English).

**Species description**
Common warthogs are distinguished by simple cone-shaped warts under the eyes of adult males, with the width of the upper face of similar proportion to the lower face (see desert warthog below), (d'Huart and Grubb 2005; de Jong et al. 2009).

**Global conservation status**
IUCN Red List Status: Least Concern.

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: Not Listed.
African Convention on the Conservation of Nature and Natural Resources: Not Listed.

***Camera-trap survey results***

**Relative abundance:** The common warthog was recorded once in the Dodori camera grid, at the same camera site as Kirk's dik-dik and lesser kudu, and twice in the Boni NR camera grid. The Boni forest camera grid images were inconclusive and there was only one confirmed event. Three other events in the Boni forest camera grid attributed to common warthog could not be fully identified to species level because of the confirmed presence of desert warthog in the same area (see below). No common warthogs were photographed at Arabuko-Sokoke Forest. These observations indicate that trapping rates for common warthog were at most below 1 / 100 days in the Boni-Dodori camera grids, jointly the least frequently recorded large mammal species (Table 25).

**Table 25** Common warthog trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 2 | 1670 | 0.18 (±0.11) |
| Boni forest | 1(+3?) | 1026 | 0.40 (±0.20) |
| Dodori NR | 1 | 1087 | 0.09 (±0.09) |
| Arabuko-Sokoke Forest | 0 | 2049 | - |

**Occupancy**: Common warthogs were detected at no more than 2 cameras in Boni forest, and at one camera each in Boni and Dodori, indicating minimal Naïve occupancy rates (Table 26).

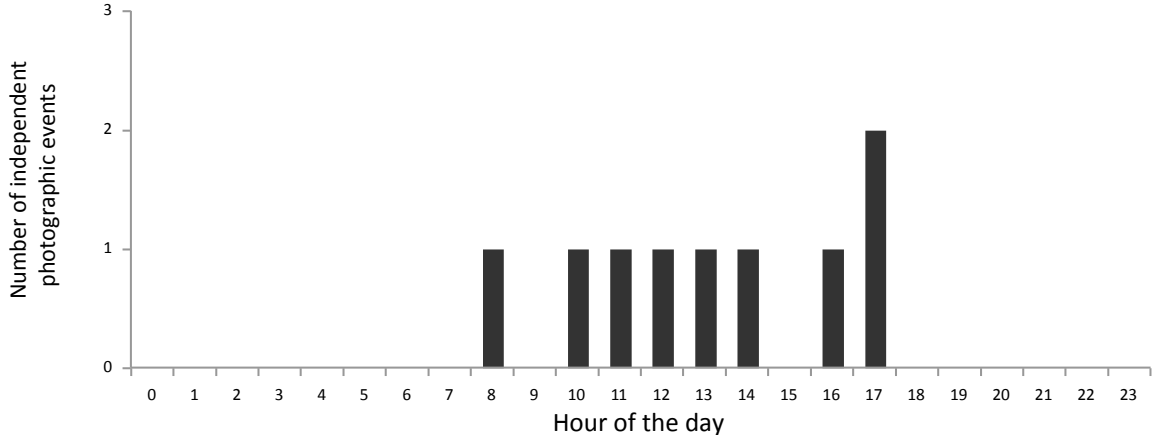
**Table 26** Naïve occupancy and modelled occupancy and detection probability estimates for the common warthog in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.05 | 0.05 (±0.00)* | 0.18 (±0.15) |
| Boni forest | 0.15 | 0.18 (±0.13)* | 0.23 (±0.13) |
| Dodori NR | 0.05 | 0.05 (±0.00)* | 0.01 (±0.01) |
| Arabuko-Sokoke Forest | N/A | N/A | N/A |

* interpret with caution; limited sample data.

**Behaviour**: The common warthog is a primarily diurnal species and all common warthog events took place in daylight, between 08:00-18:00 hours (Figure 25).

**Figure 25** Temporal distribution of common warthog records in the Boni-Dodori forest system through the 24 hour cycle.



## Summary

The common warthog is present in low numbers in the Boni-Dodori forest system (Figure 26). It appears to be living in close co-existence with two other suids: desert warthog and bushpig. The overlap of common warthog and bushpig at a single camera site was confirmed in the Boni forest camera grid. The close association between these species is unusual, although sympatry between common and desert warthog has been previously reported in Tsavo West National Park (de Jong et al. 2005). The general preference of common warthog for woodland and savannah habitats and lack of strong association with thick coastal forest habitats probably explain the overall low trapping rates reported for this species.

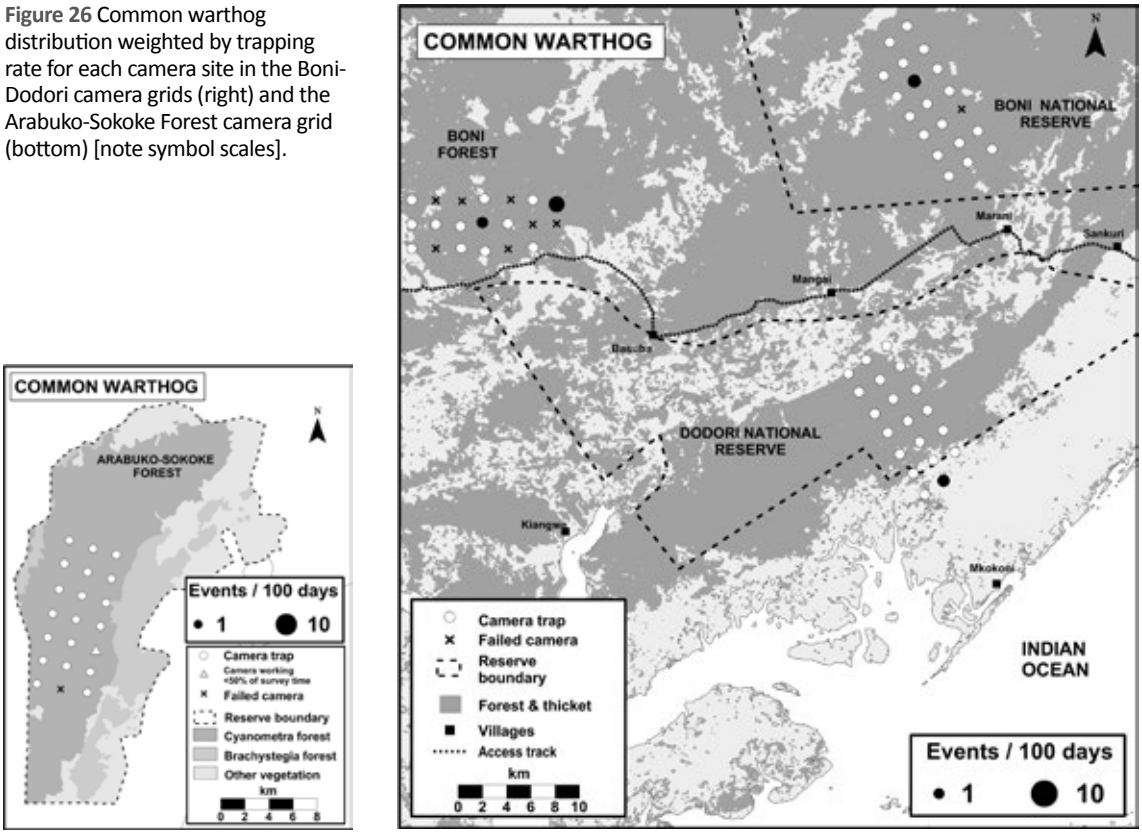



**Figure 26** Common warthog distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

## 12 *Phacochoerus aethiopicus*
(Pallas, 1766)

**Common names**
Desert warthog (English).

**Species description**
Desert warthog are distinguished by exaggerated hook shaped warts which extend from a swollen base under the eye of adult males and contribute to a much widened upper face relative to the width of the lower muzzle. Unlike common warthog, the upper ear margins tips are folded back. The skull also shows systematic differences, including rudimentary or absent lower incisors in desert warthog and there is also strong genetic support for differentiating these species (Randi et al. 2002; d'Huart and Grubb 2005).

**Global conservation status**
IUCN Red List Status: Least Concern.

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: First Schedule.
African Convention on the Conservation of Nature and Natural Resources: Not Listed.

***Camera-trap survey results***

**Relative abundance:** Desert warthog were confirmed at only one event in the Boni forest camera grid although there were three other events involving warthogs in the Boni forest camera grid where the species could not be identified with certainty. One of these involved a suspected juvenile female desert warthog showing a curled ear tip but lacking any wart development. An adult male desert warthog walked past the same camera 10 days after this event displaying a characteristic hooked genal wart (see photo above). None were recorded at Arabuko-Sokoke Forest (Table 27).

**Table 27** Desert warthog trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 0 | 1670 | - |
| Boni forest | 1(+1?) | 1026 | 0.2 (±0.14) |
| Dodori NR | 0 | 1087 | - |
| Arabuko-Sokoke Forest | 0 | 2049 | - |

**Occupancy**: The occurrence of desert warthog at a single location in the entire study implies that they are not widespread in the area (Table 28).

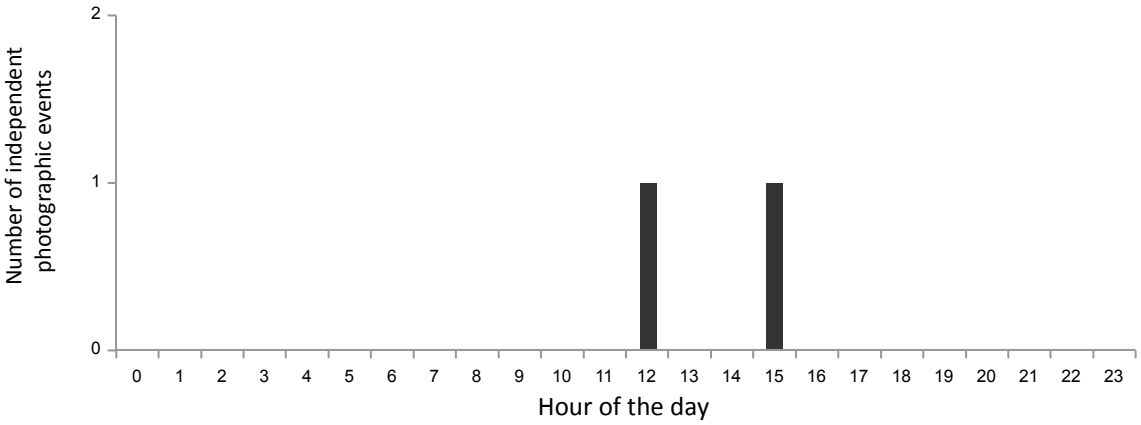
**Table 28** Naïve occupancy and modelled occupancy and detection probability estimates for the desert warthog in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | N/A | N/A | N/A |
| Boni forest | 0.08 | 0.08 (0.0)* | 0.25 (0.19) |
| Dodori NR | N/A | N/A | N/A |
| Arabuko-Sokoke Forest | N/A | N/A | N/A |

* interpret with caution; limited sample data.

**Behaviour**: The confirmed and a possible event for the species both took place in daylight (11:13 and 14:37 hours) (Figure 27).

**Figure 27** Temporal distribution of desert warthog records in the Boni-Dodori forest system through the 24 hour cycle.



## Summary

The identification of the camera-trap images as a desert warthog was confirmed independently by T. Butynski, Y. de Jong and J.P. d'Huart. The record represents a new location for this species though within the known range. Sympatric co-existence of common and desert warthog has been previously recorded in Tsavo West National Park in Kenya (de Jong et al. 2009). It is noted that neither bushpig nor common warthog were photographed at the same camera as desert warthog, but both were present at other camera sites in the same camera grid (Figure 28).

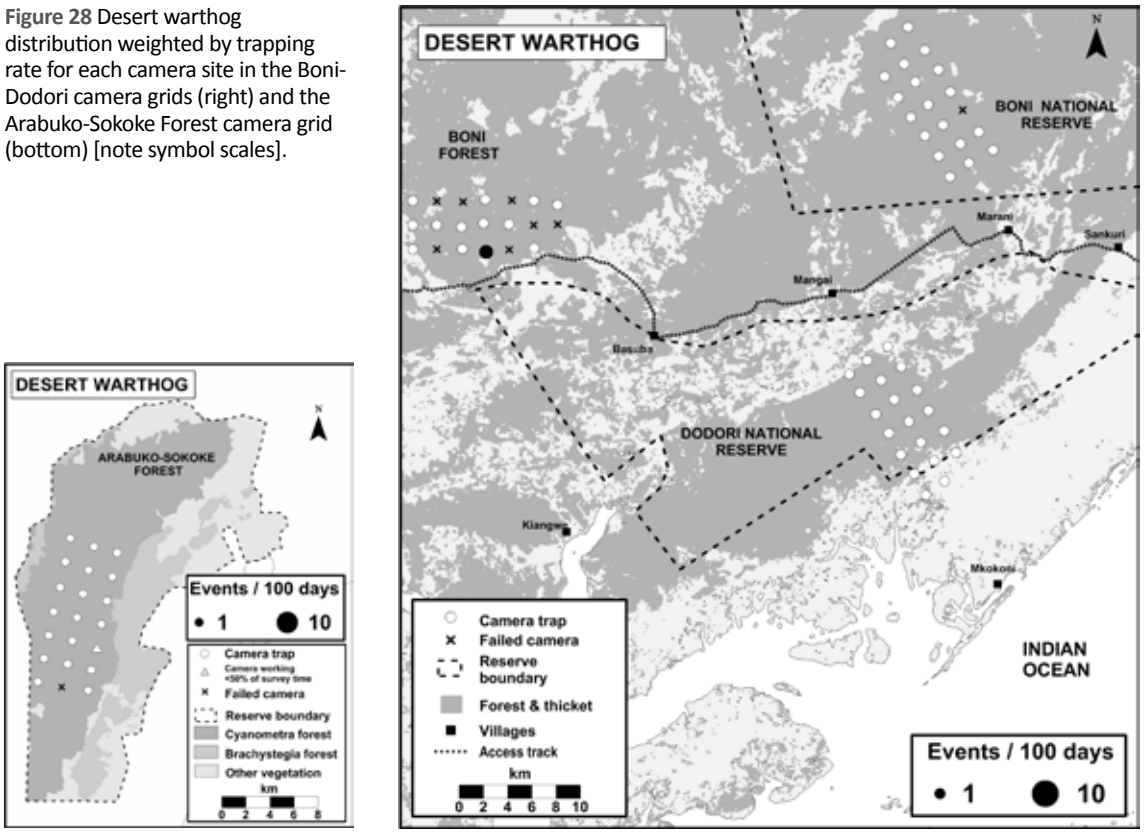



**Figure 28** Desert warthog distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

## 13 *Hippopotamus amphibius*
(Linnaeus, 1758)

**Common names**
Common Hippopotamus (English); Kiboko (Swahili)

**Species description**
The massive rounded body, superficial hairlessness, and unique head and jaws of the common hippo are unmistakeable.

**Global conservation status**
IUCN Red List Status: Vulnerable.

**Legal status**
CITES: Appendix II.
Kenya Wildlife (Conservation and Management) Act: First Schedule.
African Convention on the Conservation of Nature and Natural Resources: Class B.

***Camera-trap survey results***

**Relative abundance:** A single hippo was photographed once in the Dodori camera grid. No hippo events occurred at any other site (Table 29).

**Table 29** Hippopotamus trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 0 | 1670 | - |
| Boni forest | 0 | 1026 | - |
| Dodori NR | 1 | 1087 | 0.09 (±0.09) |
| Arabuko-Sokoke Forest | 0 | 2049 | - |

**Occupancy**: The single record implies that hippos were not widely present in the camera grids during the survey period. It is noted that the single site where hippo were recorded was close to a large waterhole in the Dodori forest, named locally as 'Kibokoni waterhole', a direct reference to the presence of hippos; "kiboko" is hippo in Kiswahili (Table 30).

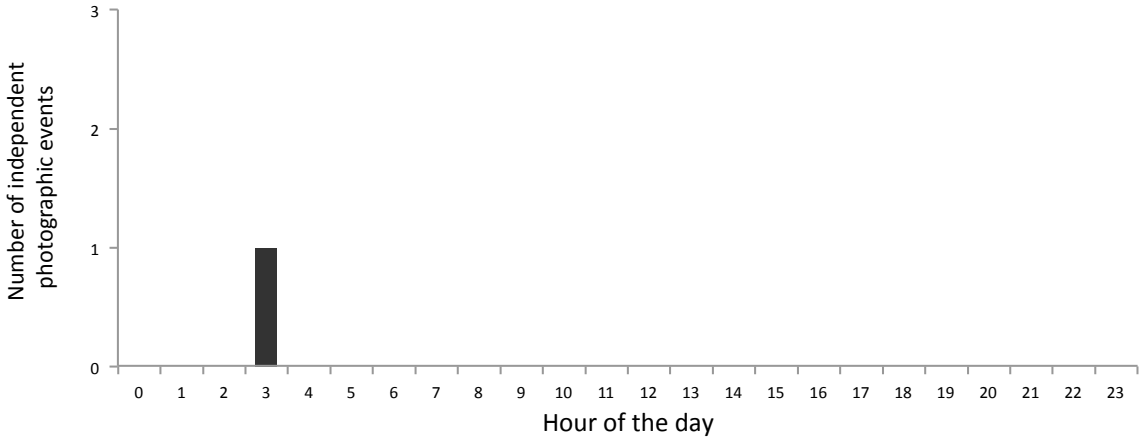
**Table 30** Naïve occupancy and modelled occupancy and detection probability estimates for the hippo in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | N/A | N/A | N/A |
| Boni forest | N/A | N/A | N/A |
| Dodori NR | 0.05 | 0.05 (±0.00)* | 0.01 (±0.01) |
| Arabuko-Sokoke Forest | N/A | N/A | N/A |

* interpret with caution; limited sample data.

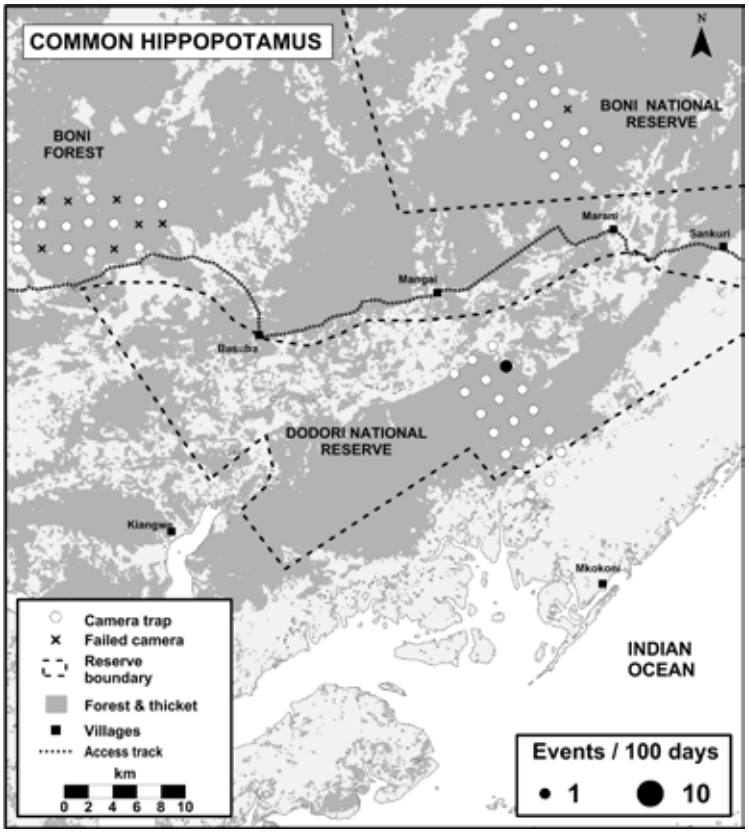
**Behaviour**: The single record was obtained at night (03:25) in keeping with known hippo grazing behaviour (Figure 29).

**Figure 29** Temporal distribution of hippopotamus records in the Boni-Dodori forest system through the 24 hour cycle.



## Summary

Hippopotamus are present along the lower Tana River and in the Tana Estuary, where their tracks may be found on salt water beaches. They also make use of several water holes adjacent to the camera grids along the Dodori river water course. The lack of records suggests that hippos do not regularly make incursions into the targeted forest areas. This is in keeping with the general habitat preference assessment that they prefer open grassland (Figure 30).



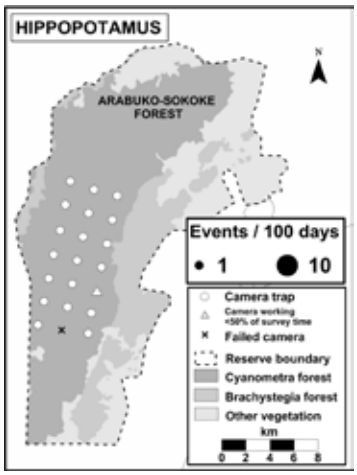




**Figure 30** Hippopotamus distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

## Carnivores

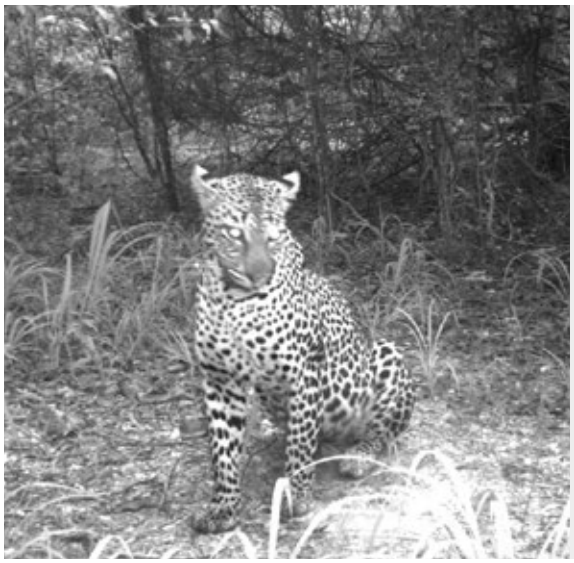
The four camera grids detected 13 species of carnivores with 349 total events. They comprise three Felidae, African lion, Leopard, Caracal; two Viverridae, African civet, Central African large-spotted genet; one Hyaenidae, Spotted hyaena, one Canidae, African wild dog; five Herpestidae, Common dwarf mongoose, Marsh mongoose, Slender mongoose, Sokoke bushy-tailed mongoose, White tailed mongoose; and one Mustelidae, Honey badger.

Across all sites, the most frequently encountered carnivore was the Sokoke bushy-tailed mongoose (117 events) followed by the Large-spotted genet (89 events), Leopard (67 events) and Spotted Hyaena (26 events). The remaining nine carnivore species were recorded with less than 15 events each.

The three camera grids in the Boni-Dodori system recorded similar numbers of carnivore species (eight, nine and eight respectively); with Boni forest recording the highest number of events. Only five carnivore species were detected at the Arabuko-Sokoke *Cynometra* forest camera grid.

## 14 *Panthera pardus*
(Linnaeus, 1758)

**Common names**
Leopard (English), Chui (Swahili).



**Species description**
Leopards are medium sized cats measuring up to 80 cm at the shoulder and weighing up to 90 kg. In camera-trap images leopards are recognisable by the arrangement of spots in rosette patterns which distinguishes them from the solid spots of other medium sized spotted cats. Melanistic forms are sometimes seen, but none were recorded in this survey.

**Global conservation status**
IUCN Red List Status: Near Threatened.

**Legal status**
CITES: Appendix I.
Kenya Wildlife (Conservation and Management) Act: First Schedule.
African Convention on the Conservation of Nature and Natural Resources: Class B.

***Camera-trap survey results***

**Relative abundance:** Leopard were recorded in 67 events across the Boni-Dodori camera grids. There were no events in the Arabuko-Sokoke Forest camera grid (Table 31). The highest trapping rates occurred in the Boni forest camera grid (4.30) with the Boni NR (1.09) and Dodori NR (0.35) camera grids.

**Table 31** Leopard trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 19 | 1670 | 1.09 (±0.32) |
| Boni forest | 43 | 1026 | 4.30 (±0.73) |
| Dodori NR | 5 | 1087 | 0.35 (±0.17) |
| Arabuko-Sokoke Forest | 0 | 2049 | - |

**Occupancy**: In the Boni forest camera grids, events occurred at 92% of fully operational camera sites compared to ca. 20% of sites in Dodori. These occupancy estimates suggest the leopard occurs inland more frequently than near the coast. No events took place at the Arabuko-Sokoke Forest camera grid (Table 32).

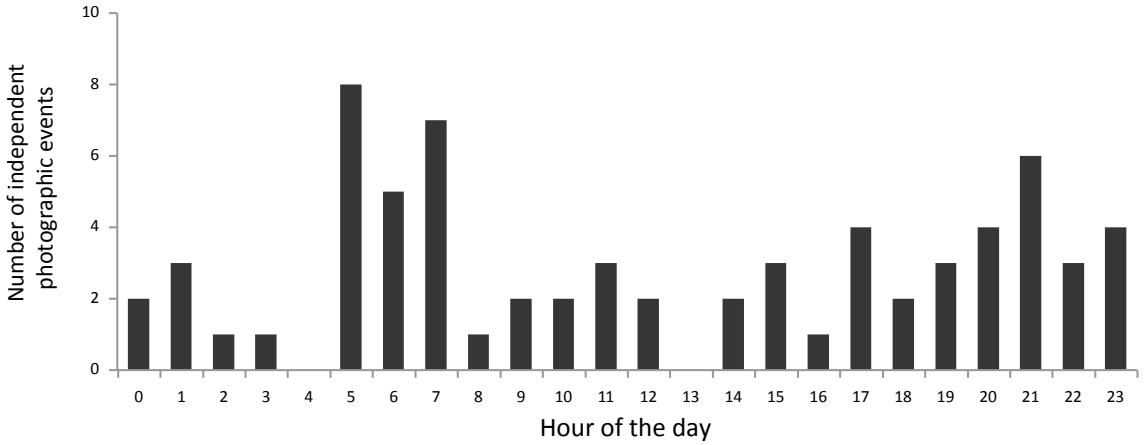
**Table 32** Naïve occupancy and modelled occupancy and detection probability estimates for the leopard in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.47 | 0.74 (±0.25)* | 0.12 (±0.05) |
| Boni forest | 0.92 | 1.00 (±0.00) | 0.31 (±0.05) |
| Dodori NR | 0.20 | 1.00 (±0.09)* | 0.04 (±0.02) |
| Arabuko-Sokoke Forest | N/A | N/A | N/A |

* interpret with caution; limited sample data.

**Behaviour**: Leopards were active throughout the day and night but with a peak around dawn (05:00-08:00) and another peak after sunset (17:00-21:00). Leopards are considered diurnal but hunting often occurs at night (Kingdon 1997) (Figure 31).

**Figure 31** Temporal distribution of leopard records in the Boni-Dodori forest system through the 24 hour cycle.



## Summary

Leopards were regularly encountered in the Boni-Dodori camera grids (Figure 32), with images showing single individuals and at least one sequence of a female accompanied by a well grown offspring. A study is planned to see if individual identity based on individual spot patterns can produce at least a minimum estimate of the number of individuals recorded in each camera grid. Leopards were expected at Arabuko-Sokoke Forest. They have been recorded there in the past. But the failure to detect any over >2000 days of camera-trapping suggests that they are much reduced in this protected area compared to the northern forests.

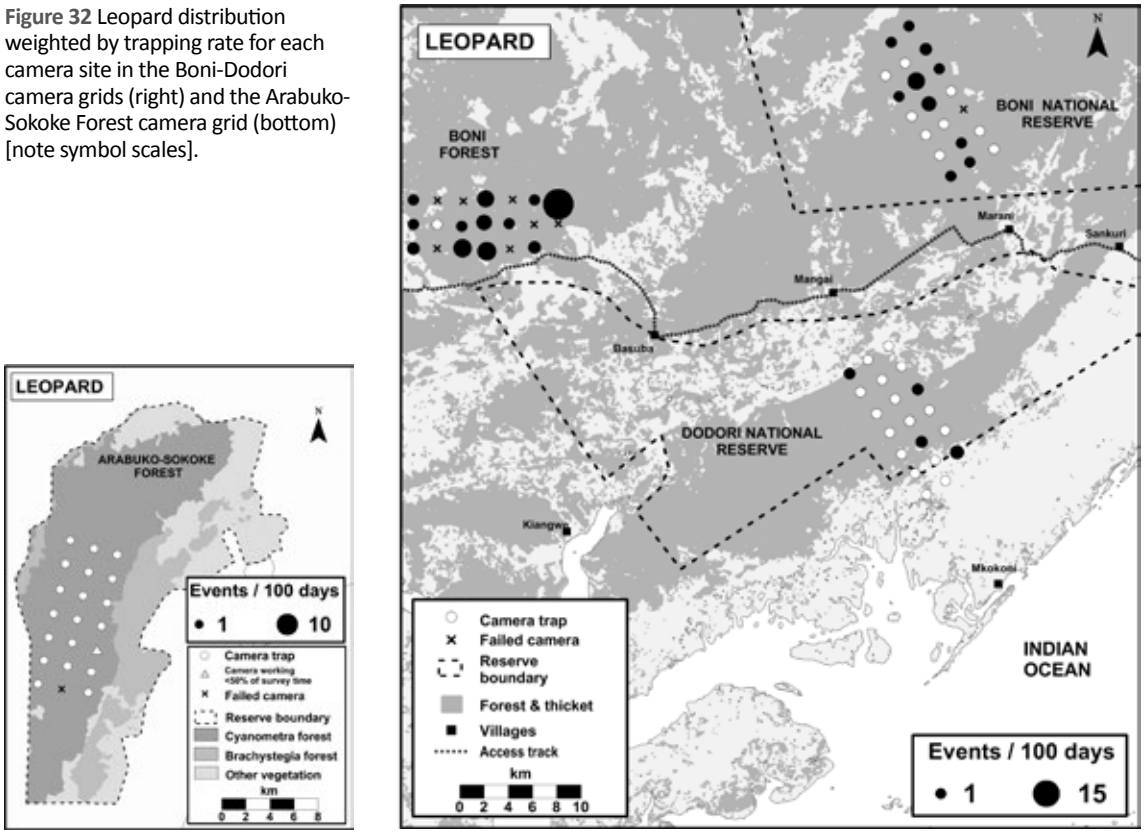



**Figure 32** Leopard distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

## 15 *Panthera leo*

(Linnaeus, 1758)

**Common names**
African lion (English); Simba (Swahili).

**Species description**
The African lion well known and distinctive. Males are larger than females and may show a thick mane, although this is believed to be less developed in the lions of coastal eastern Kenya. In camera-trap images adult lions are unmistakable due to their size and the absence of spots.

**Global conservation status**
IUCN Red List Status: Vulnerable.

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: First Schedule.
African Convention on the Conservation of Nature and Natural Resources: Not Listed.

***Camera-trap survey results***

**Relative abundance:** There was only one event where the African lion was recorded in the Boni forest camera grid (Table 33).

**Table 33** Lion trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 0 | 1670 | - |
| Boni forest | 1 | 1026 | 0.10 (±0.10) |
| Dodori NR | 0 | 1087 | - |
| Arabuko-Sokoke Forest | 0 | 2049 | - |

**Occupancy**: The African lion was detected at a single site in the Boni forest camera grid (Table 34).

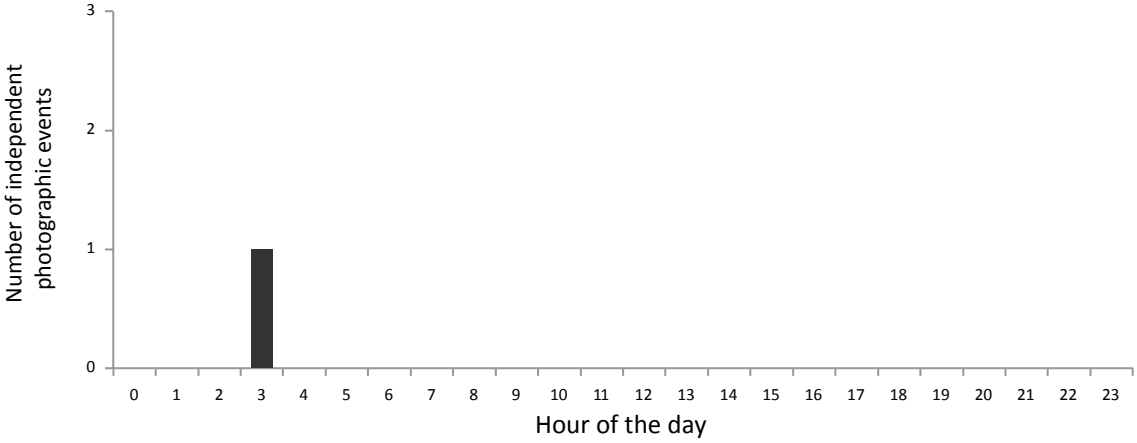
**Table 34** Naïve occupancy and modelled occupancy and detection probability estimates for the African lion in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | N/A | N/A | N/A |
| Boni forest | 0.08 | 0.08 (±0.0)* | 0.01 (±0.01) |
| Dodori NR | N/A | N/A | N/A |
| Arabuko-Sokoke Forest | N/A | N/A | N/A |

* interpret with caution; limited sample data.

**Behaviour**: This species is mainly diurnal but hunts at night; the single event took place at night (Figure 33).

**Figure 33** Temporal distribution of African lion records in the Boni-Dodori forest system over a 24 hour period.



## Summary

The African lion is classified as Vulnerable, with growing concern at the declining trend in it's population size. Based on IUCN Red List distribution information and other documentation of Arabuko-Sokoke Forest, lions have not been recorded there in recent times. The single record from Boni forest (Figure 34) also lies outside the distribution areas currently indicated by IUCN. Because the camera grids were focused on forest and thicket habitat, rather than more open grasslands of the associated habitat mosaic, they may not be best placed to sample lion presence. Consequently the low detection rate is of itself less significant; than the confirmation of lions using the region.

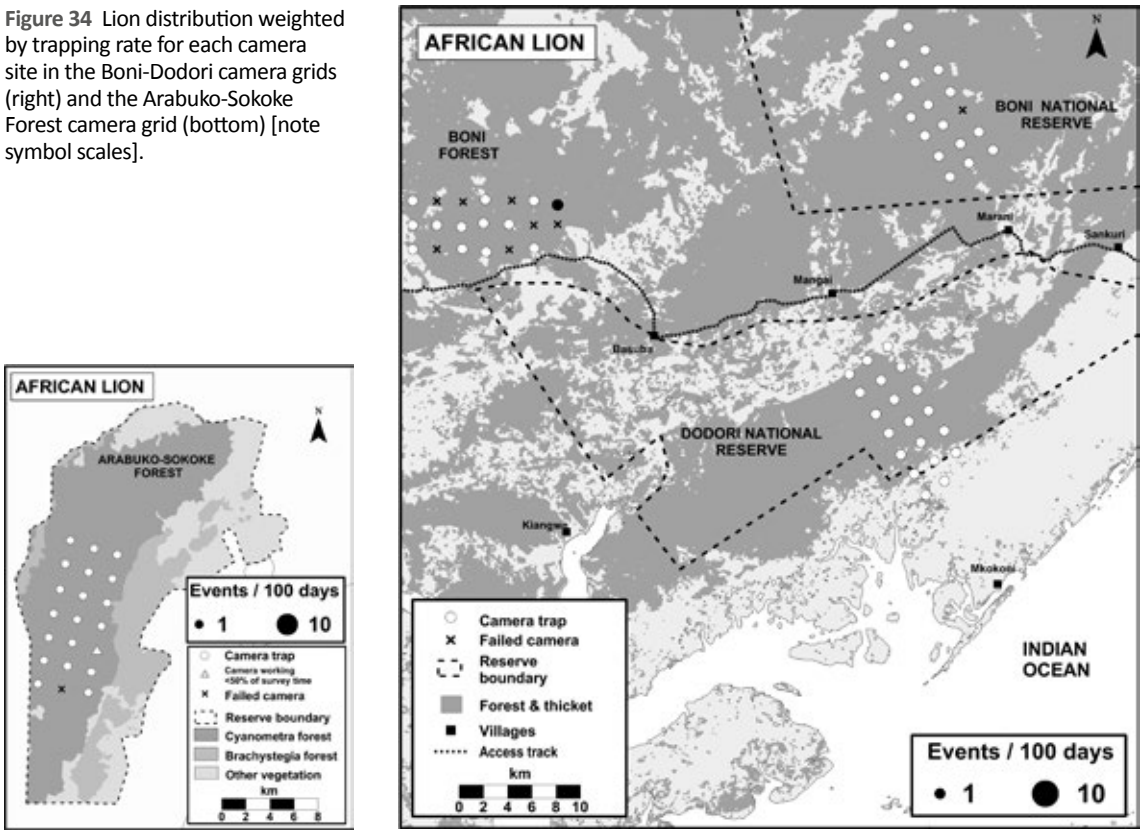



**Figure 34** Lion distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

# 16 *Caracal caracal*
(Schreber, 1776)

**Common names**
Caracal (English), Simba mangu (Swahili).

**Species description**
The caracal is a medium sized cat 62-91 cm long and 50 cm high at the shoulder. It has a thick coat which varies in colour from tawny grey to reddish to sandy yellow. Caracals are distinctive cats with prominent and uniquely tasselled ears, making them unlikely to be mistaken for other species in clear camera-trap images (see summary for discussion of Golden cat *Caracal aurata*).

**Global conservation status**
IUCN Red List Status: Least Concern.

**Legal status**
CITES: Appendix II.
Kenya Wildlife (Conservation and Management) Act: Third Schedule.
African Convention on the Conservation of Nature and Natural Resources: Class B.

***Camera-trap survey results***

**Relative abundance:** The caracal was infrequently recorded in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. It was one of the three species of carnivores recorded in Arabuko-Sokoke Forest (Table 35).

**Table 35** Caracal trapping rates in the Boni, Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 6 | 1670 | 0.36 (±0.14) |
| Boni forest | 0 | 1026 | - |
| Dodori NR | 4 | 1087 | 0.35 (±0.17) |
| Arabuko-Sokoke Forest | 3 | 2049 | 0.15 (±0.09) |

**Occupancy**: Naïve occupancy for the caracal was similar in the Boni, Dodori and Arabuko-Sokoke Forest camera grids (range 0.11 – 0.16). It was not encountered in Boni forest (Table 36).

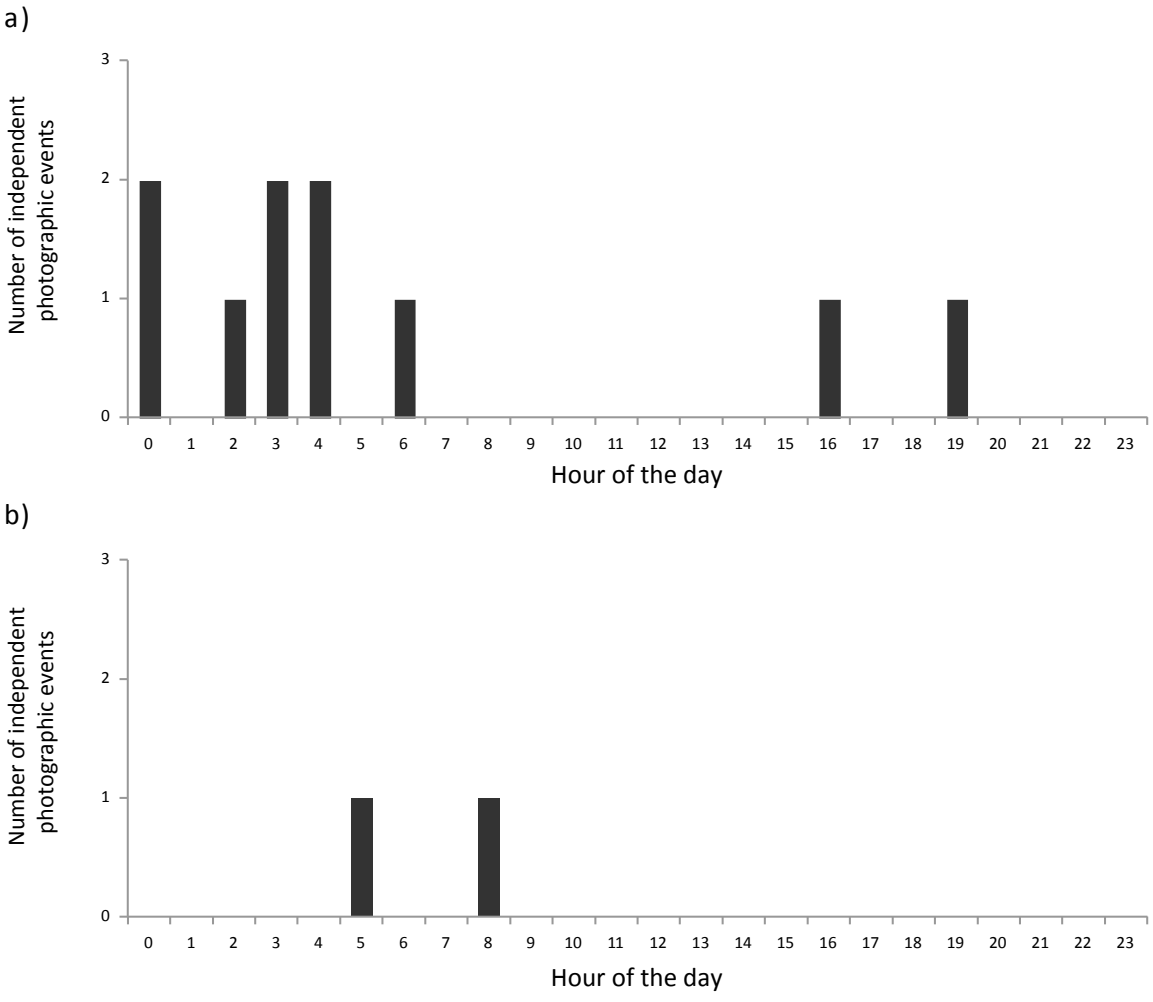
**Table 36** Naïve and modelled occupancy and detection probability estimates for the caracal in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.11 | 0.12(±0.09)* | 0.22(±0.12) |
| Boni forest | N/A | N/A | N/A |
| Dodori NR | 0.15 | 0.26 (±0.20)* | 0.15 (±0.13) |
| Arabuko-Sokoke Forest | 0.16 | 1.00 (±0.09)* | 0.02 (±0.01) |

* interpret with caution; limited sample data.

**Behaviour**: Caracal are known to be active at all hours of the day but in the study areas the majority of records occurred at night (Figure 35).

**Figure 35** Temporal distribution of caracal records in (a) the Boni-Dodori forest system and (b) the Arabuko-Sokoke forest through the 24 hour cycle.



## Summary

Although the sample size is small this is another species where detection by camera-trap occurred at higher rates in the northern reserves than Arabuko-Sokoke Forest (Figure 36). Note that a single sighting record of golden cat (*Caracal aurata*) has been reported from Arabuko-Sokoke Forest (Butynski et al. 2012) and as a result it has been suggested that golden cat might be expected in the northern coastal forests as well. Partial or unclear images of a caracal might look similar to a golden cat in some situations, but in the event no caracal images were ambivalent in this way and there was no evidence for presence of golden cat in any of the survey grids in this study.

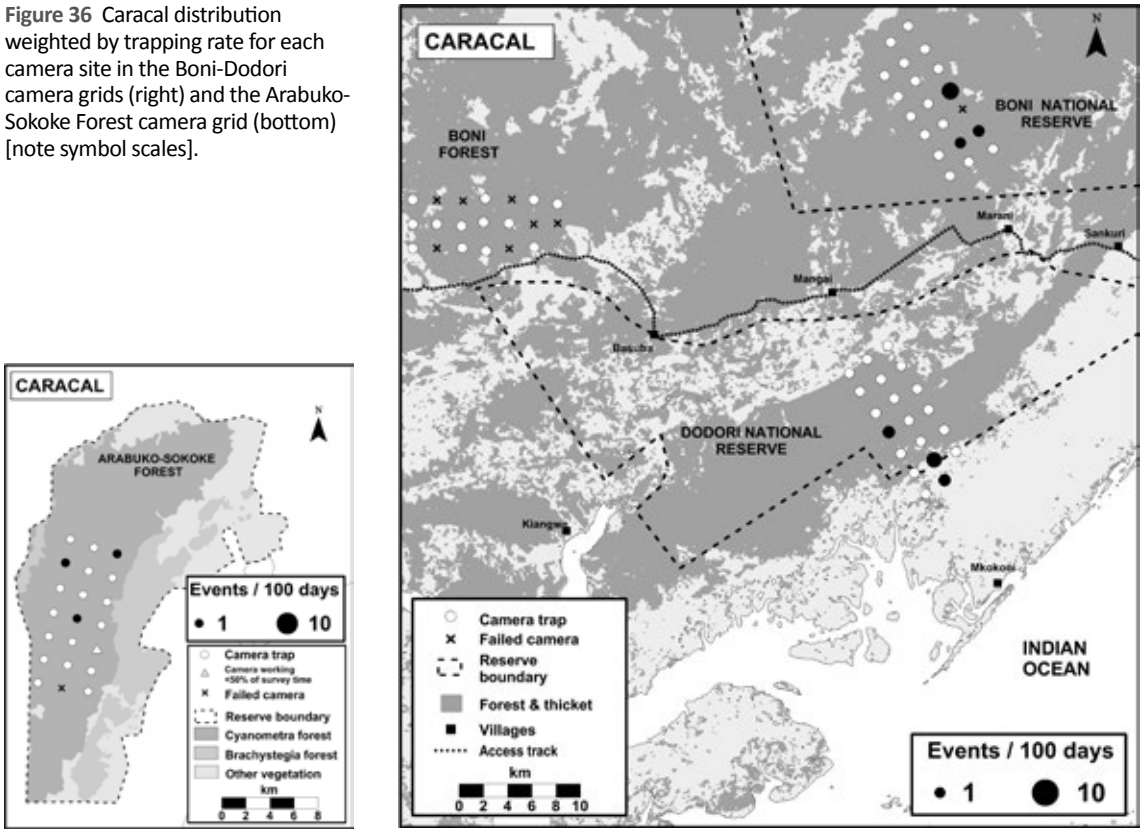



**Figure 36** Caracal distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

## 17 *Civettictis civetta*

(Schreber, 1776)

**Common names**
African civet (English); Ngawa (Swahili).

**Species description**
The species is easily distinguishable in camera-trap images. The intermediate body size, rather dog-like head, and distinctive blotched and striped coat pattern, with dark facial mask and white neck stripes all distinguish from other small spotted carnivores.

**Global conservation status**
IUCN Red List Status: Least Concern.

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: Not Listed.
African Convention on the Conservation of Nature and Natural Resources: Not Listed.

***Camera-trap survey results***

**Relative abundance:** The African civet was recorded in four separate events in three different camera locations within the Dodori camera-trap grid (Table 37).

**Table 37** African civet trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 0 | 1670 | - |
| Boni forest | 0 | 1026 | - |
| Dodori NR | 4 | 1087 | 0.35 (±0.17) |
| Arabuko-Sokoke Forest | 0 | 2049 | - |

**Occupancy**: The African civet was only detected in the Dodori NR in three camera stations (Table 38).

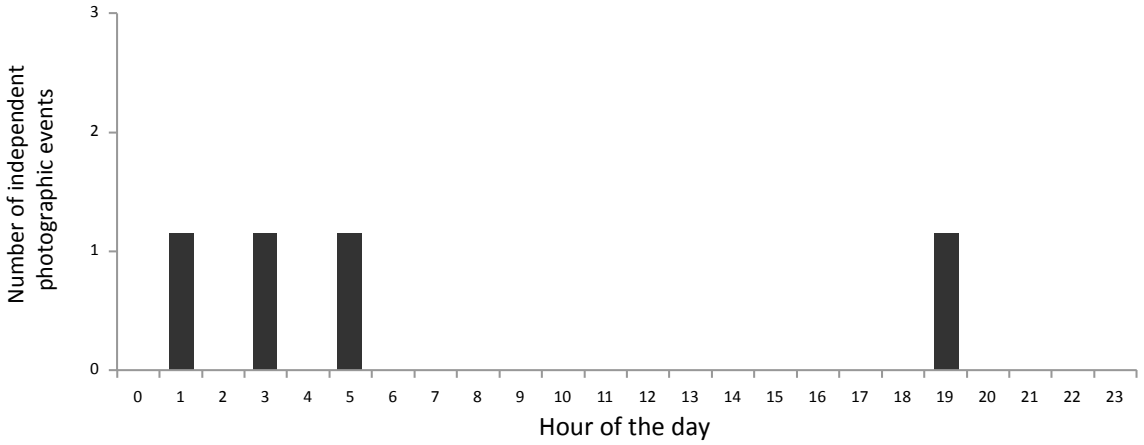
**Table 38** Naïve and modelled occupancy and detection probability estimates for the African civet in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | N/A | N/A | N/A |
| Boni forest | N/A | N/A | N/A |
| Dodori NR | 0.15 | 0.14 (±0.11)* | 0.21 (±0.17) |
| Arabuko-Sokoke Forest | N/A | N/A | N/A |

* interpret with caution; limited sample data.

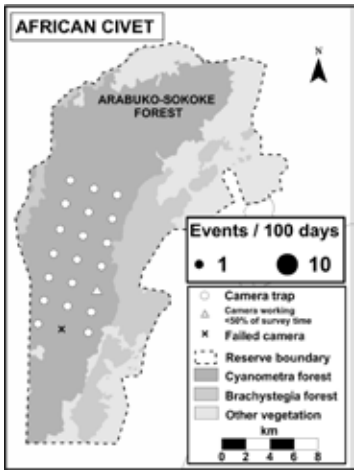
**Behaviour**: The African civet was found to be nocturnal (Figure 37).

**Figure 37** Temporal distribution of African civet records in Dodori NR through the 24 hour cycle.



## Summary

In this study, African civet were only detected in Dodori NR (Figure 38). The use of varied habitats including forest, woodland and grassland mosaic with aquatic environments is characteristic of the species (Kingdon and Hoffmann 2013). Dodori is also the only site where woodland/savannah adapted species such as lesser kudu and dik-dik were also detected along with species inhabiting river courses and water bodies, hippopotamus and marsh mongoose.



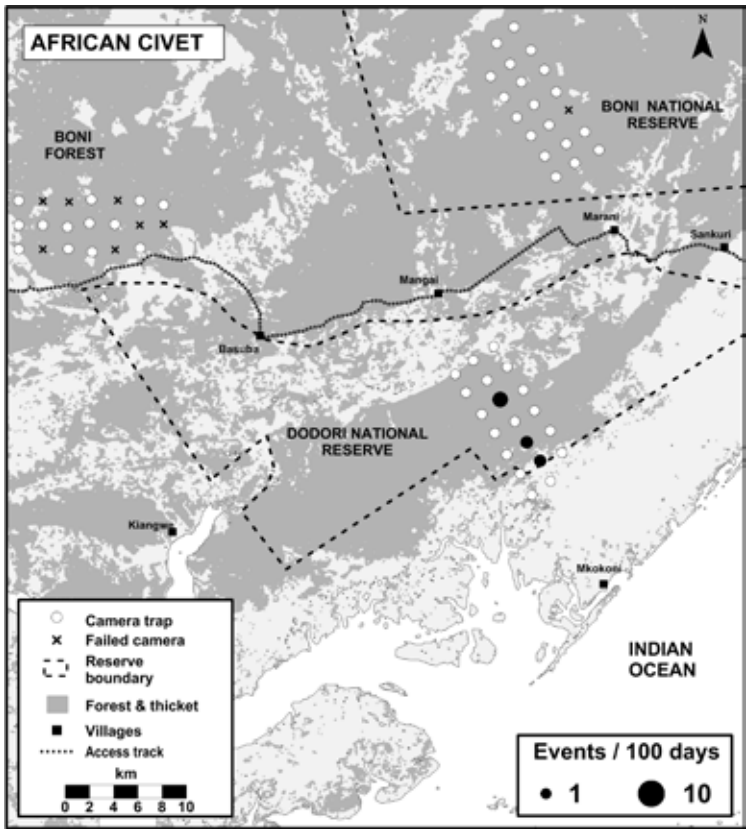




**Figure 38** African civet distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

## 18 *Genetta maculata*

(Gray, 1830)

**Common names**
Central African large-spotted genet (English); Kanu (Swahili).

**Species description**
The large-spotted genet is an agile small predator with a grey to sandy coloured coat, rows of dark markings running longitudinally down its body, broad dark rings on the tail and pale leg colouring. On distributional grounds, there is a possibility of overlap with the common genet. Although image quality did not allow firm identification in all cases, all individuals in this study have been identified as large-spotted genets as this is a forest associated species. All clear images consistently showed features of large-spotted genet unlike the smaller wider spaced spots narrower tail rings and dark hind legs of the common genet.

**Global conservation status**
IUCN Red List Status: Least Concern.

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: First Schedule.
African Convention on the Conservation of Nature and Natural Resources: Not Listed.

***Camera-trap survey results***

**Relative abundance:** The large-spotted genet was the most frequently recorded carnivore species overall and at Arabuko-Sokoke Forest the second most frequently encountered species after suni. In the Boni-Dodori forest system it was encountered most often in the Dodori camera grids where trapping rates were three and six times greater than those in the Boni forest and national reserve camera grids respectively (Table 39).

**Table 39** Large-spotted genet trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 8 | 1670 | 0.48 (±0.16) |
| Boni forest | 10 | 1026 | 0.90 (±0.32) |
| Dodori NR | 32 | 1087 | 2.81 (±0.49) |
| Arabuko-Sokoke Forest | 39 | 2049 | 1.88 (±0.33) |

**Occupancy**: The large-spotted genet was detected throughout the four camera grids with detections at 70% of the camera sites in the Dodori camera grid and 38-46% of the camera sites in the Boni and Arabuko-Sokoke Forest camera grids (Table 40).

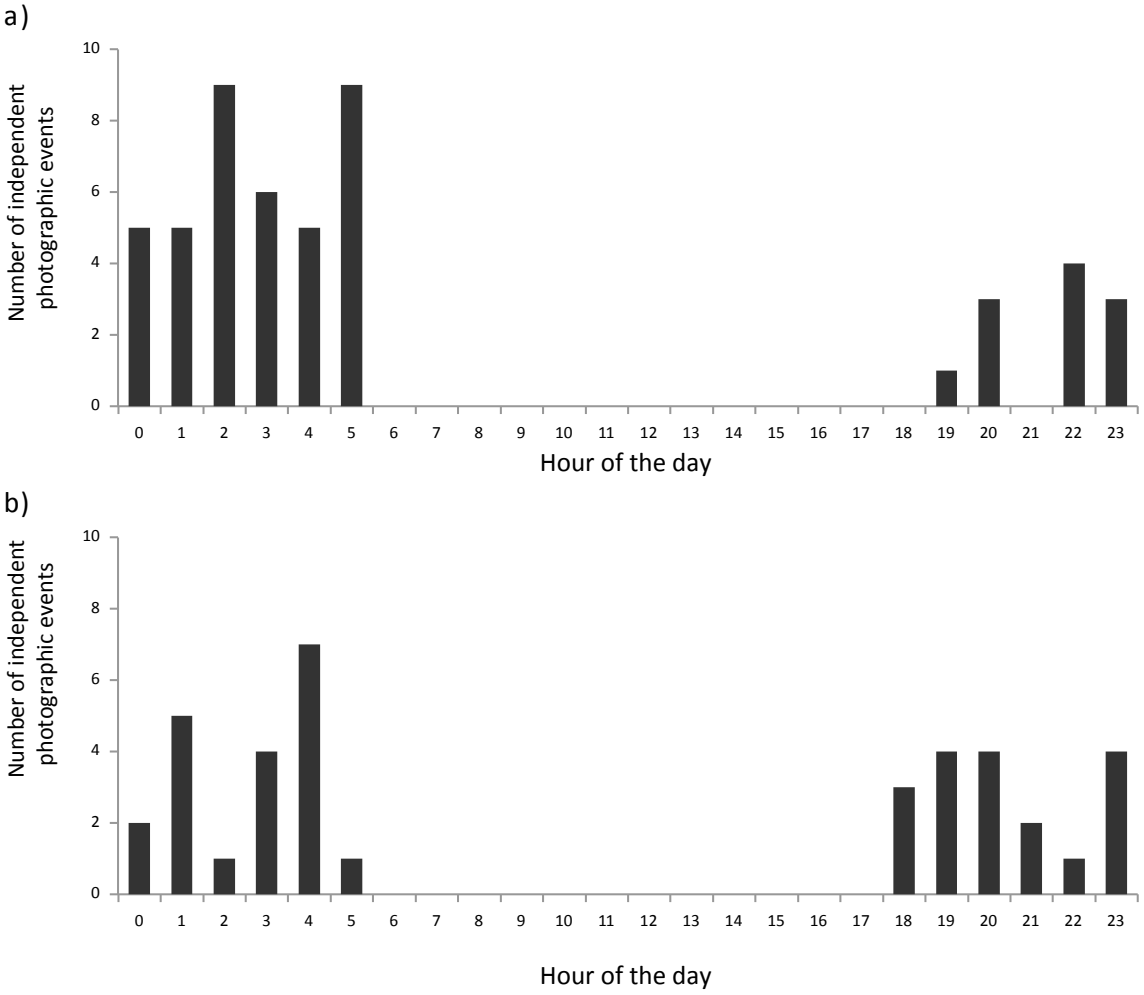
**Table 40** Naïve and modelled occupancy and detection probability estimates for the large-spotted genet in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.37 | 1.00 (±0.06)* | 0.05 (±0.02) |
| Boni forest | 0.46 | 0.72 (±0.31)* | 0.13 (±0.07) |
| Dodori NR | 0.70 | 0.84 (±0.15) | 0.28 (±0.06) |
| Arabuko-Sokoke Forest | 0.47 | 0.49 (±0.12) | 0.28 (±0.05) |

* interpret with caution; limited sample data.

**Behaviour**: The large-spotted genet displayed nocturnal behaviour with events occurring from 19:00 to 06:00 (Figure 39).

**Figure 39** Temporal distribution of large-spotted genet records in (a) the Boni-Dodori forest system and (b) the Arabuko-Sokoke forest through the 24 hour cycle.



## Summary

The large-spotted genet was recorded consistently across all four forest reserves (Figure 40). Activity patterns confirm that the most frequently recorded small predator in these habitats is strictly nocturnal. Not all images of genets in this data set were sufficiently clear to confirm species identity, but it is assumed that only one species is involved on the basis of habit and consistent appearance of individuals in the clear images.

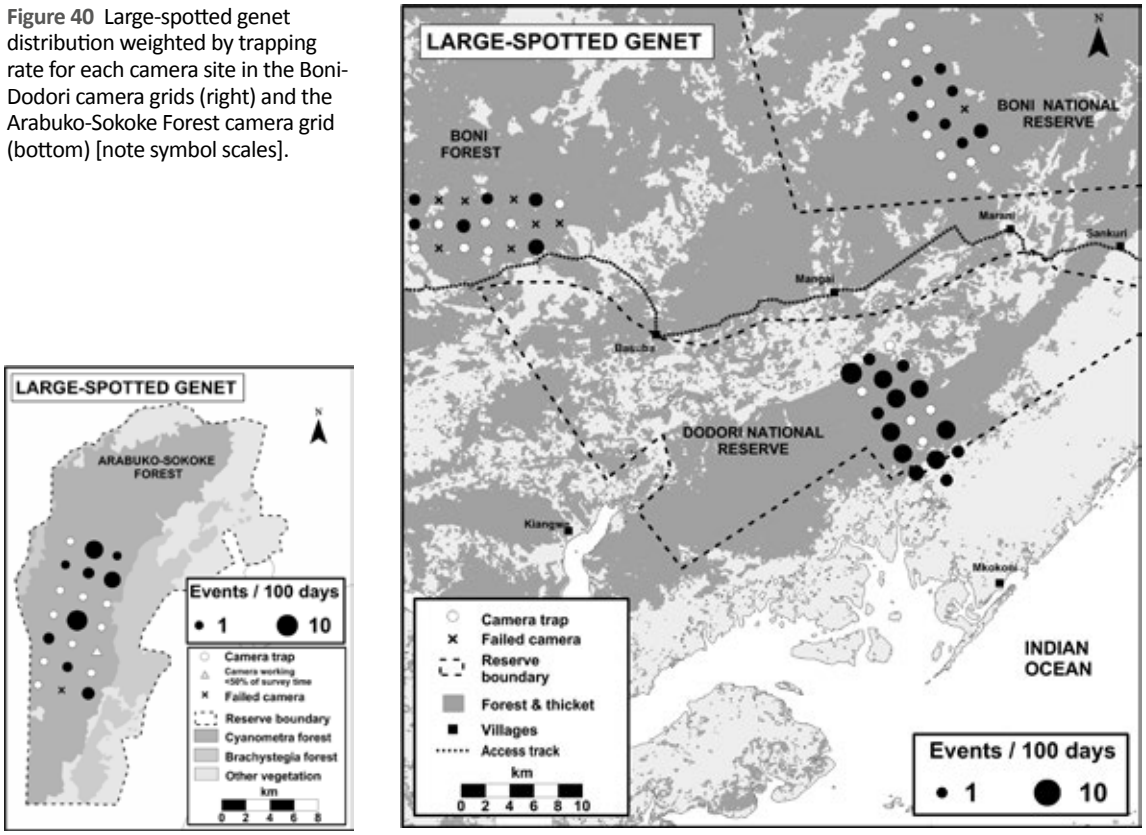



**Figure 40** Large-spotted genet distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

## 19 *Crocuta crocuta*
(Erxleben, 1777)

**Common names**
Spotted hyaena (English); Fisi (Swahili).

**Species description**
The spotted hyaena is a large carnivore, 100-180 cm long and 75-90 cm tall at the shoulder. The uneven spotting and typical body shape is distinctive in camera-trap images.

**Global conservation status**
IUCN Red List Status: Least Concern.

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: Not Listed.
African Convention on the Conservation of Nature and Natural Resources: Not Listed.

***Camera-trap survey results***

**Relative abundance:** The spotted hyaena was recorded at very low frequency in the Boni-Dodori camera grids (trapping rate < 1) (Table 41).

**Table 41** Spotted hyaena trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 9 | 1670 | 0.54 (±0.19) |
| Boni forest | 8 | 1026 | 0.80 (±0.30) |
| Dodori NR | 9 | 1087 | 0.79 (±0.35) |
| Arabuko-Sokoke Forest | 0 | 2049 | - |

**Occupancy**: The spotted hyaena was detected in all the Boni-Dodori camera grids (Table 42). It was not recorded in Arabuko-Sokoke Forest.

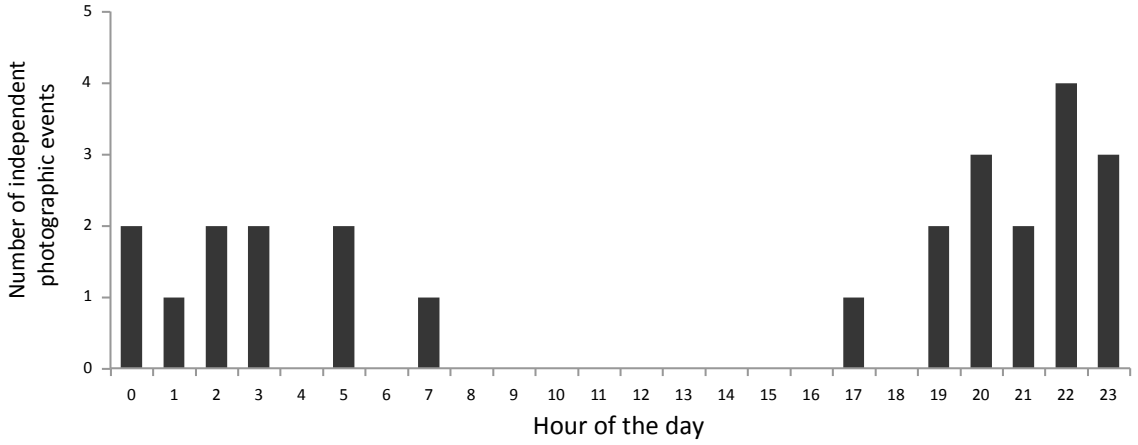
**Table 42** Naïve and modelled occupancy and detection probability estimates for the spotted hyaena in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.26 | 0.40 (±0.20)* | 0.12 (±0.06) |
| Boni forest | 0.31 | 0.39 (±0.18)* | 0.19 (±0.09) |
| Dodori NR | 0.15 | 0.19 (±0.11)* | 0.27 (±0.14) |
| Arabuko-Sokoke Forest | N/A | N/A | N/A |

* interpret with caution; limited sample data.

**Behaviour**: Although spotted hyaena are known to be both nocturnal and diurnal, in the study area they were recorded predominantly at night, with records from 17:00 to 08:00, with a peak in activity between 20:00 and 00:00 (Figure 41).

**Figure 41** Temporal distribution of spotted hyaena records in the Boni-Dodori forest system through the 24 hour cycle.



## Summary

The failure to detect spotted hyaenas in the Arabuko-Sokoke Forest (Figure 42) may be further indication of the human pressure on larger species in this area compared to the Boni-Dodori region. Although conservation status is classified as 'Least Concern' by IUCN, it is noted that the population trend is considered to be decreasing. This is another species apparently doing better in the relatively less developed region of Boni-Dodori.

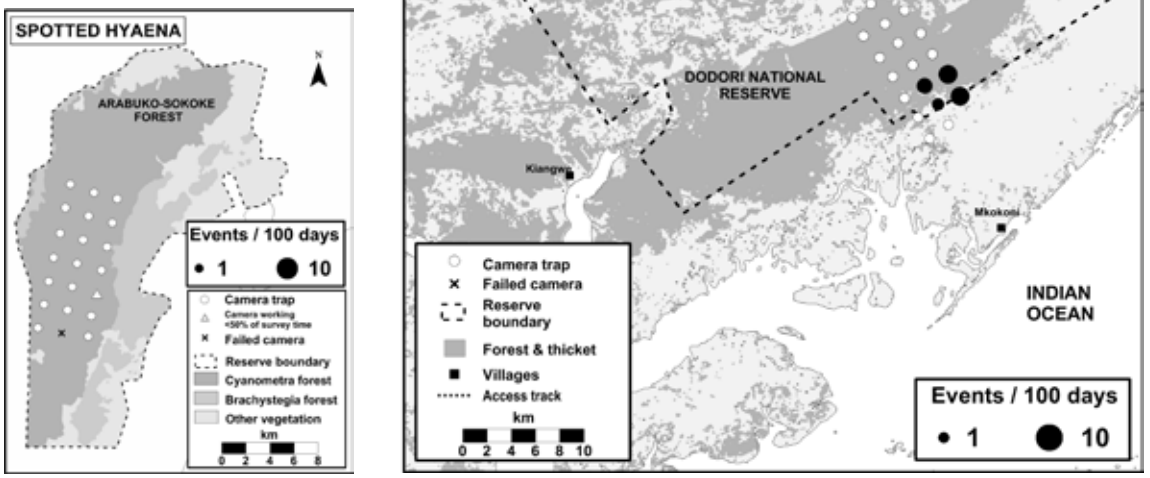



**Figure 42** Spotted hyaena distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest sampling grid (bottom) [note symbol scales].

## 20 *Lycaon pictus*
(Schreber, 1776)

**Common names**
African wild dog, Hunting dog, Painted dog (English); Mbwa Mwitu (Swahili).

**Species description**
A large dog with long slim legs, large rounded black ears, white tail tip and variable pelage pattern, making this species easily recognisable. Each animal's pelage colouration is unique making it reliable to identify individuals in clear views, although the images obtained were insufficiently clear to apply this in this camera-trap study.

**Global conservation status**
IUCN Red List Status: Endangered.

**Legal status**
CITES: Appendix I.
Kenya Wildlife (Conservation and Management) Act: Listed.
African Convention on the Conservation of Nature and Natural Resources: Listed.

***Camera-trap survey results***

**Relative abundance:** The African wild dog was only recorded at the Boni camera grid with a total of 3 events across three cameras (Table 43). A maximum of three individuals were detected at one event.

**Table 43** Wild dog trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 3 | 1670 | 0.18 (±0.10) |
| Boni forest | 0 | 1026 | - |
| Dodori NR | 0 | 1087 | - |
| Arabuko-Sokoke Forest | 0 | 2049 | - |

**Occupancy**: The wild dog was recorded at three cameras in the Boni NR camera grid (Table 44).

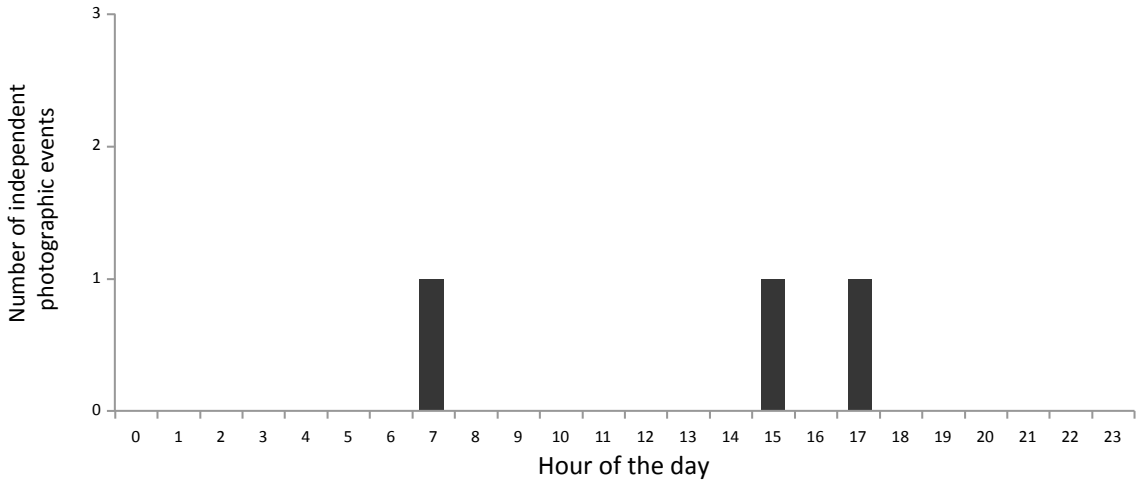
**Table 44** Naïve and modelled occupancy and detection probability estimates for the wild dog in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.16 | 0.99 (±0.11)* | 0.02 (±0.01) |
| Boni forest | N/A | N/A | N/A |
| Dodori NR | N/A | N/A | N/A |
| Arabuko-Sokoke Forest | N/A | N/A | N/A |

* interpret with caution; limited sample data.

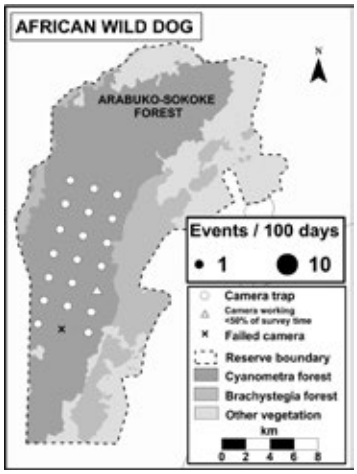
**Behaviour**: All images of the wild dog were captured in daylight. Events occurred between 07:00 and 18:00 (Figure 43).

**Figure 43** Temporal distribution of wild dog records in Boni NR through the 24 hour cycle.



## Summary

The presence of the Endangered African wild dog in the interior of Boni NR (Figure 44) is further evidence of the conservation importance of these reserves. Although the number of events is few and occur over a short time period, this pattern is typical of the ecology of this wide ranging species, which tends to occur at low density throughout its range.



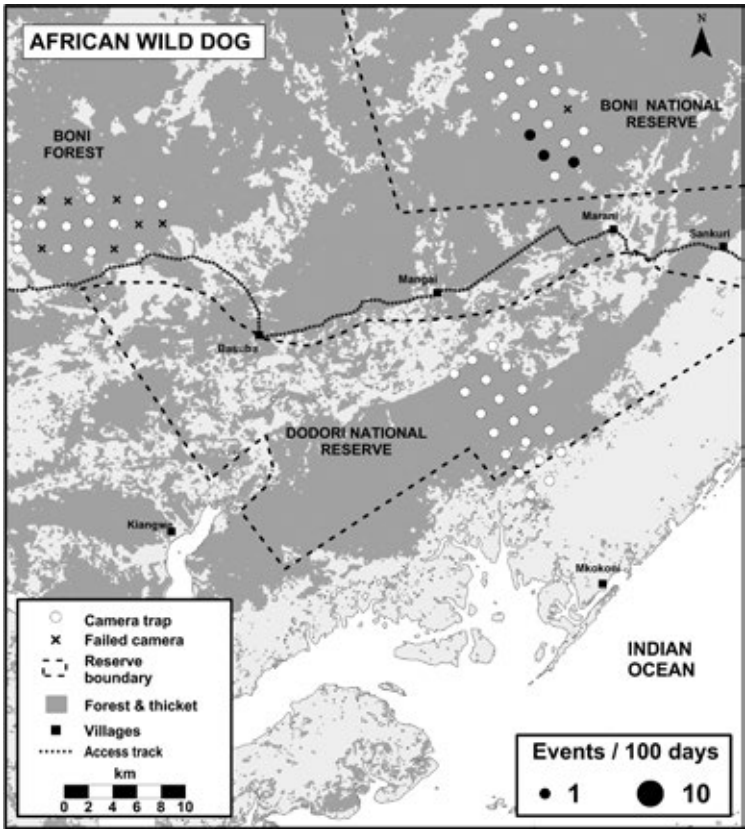




**Figure 44** Wild dog distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

## 21 *Mellivora capensis*
(Schreber, 1776)

**Common names**
Honey badger, Ratel (English); Nyegere (Swahili).

**Species description**
The honey badger is a large mustelid, 55-77 cm long and 28 cm at the shoulder. Most show a sharp divide between their black lower body and silver or grey upper body. Although all black individuals, particularly in forest environments, are known, all individuals photographed in this study were of the typical form.

**Global conservation status**
IUCN Red List Status: Least Concern.

**Legal status**
CITES: Appendix III.
Kenya Wildlife (Conservation and Management) Act: First Schedule.
African Convention on the Conservation of Nature and Natural Resources: Not Listed.

***Camera-trap survey results***

**Relative abundance:** Honey badger were infrequently recorded in all four camera grids, with the highest number of events (4) in the Boni camera grid (Table 45).

**Table 45** Honey badger trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 4 | 1670 | 0.24 (±0.12) |
| Boni forest | 1 | 1026 | 0.10 (±0.10) |
| Dodori NR | 2 | 1087 | 0.18 (±0.12) |
| Arabuko-Sokoke Forest | 1 | 2049 | 0.05 (±0.05) |

**Occupancy**: Honey badgers were detected in all the camera grids with the highest naïve occupancy in the Boni NR camera grid and very low naïve occupancy (±0.1) in the rest of the camera grids (Table 46).

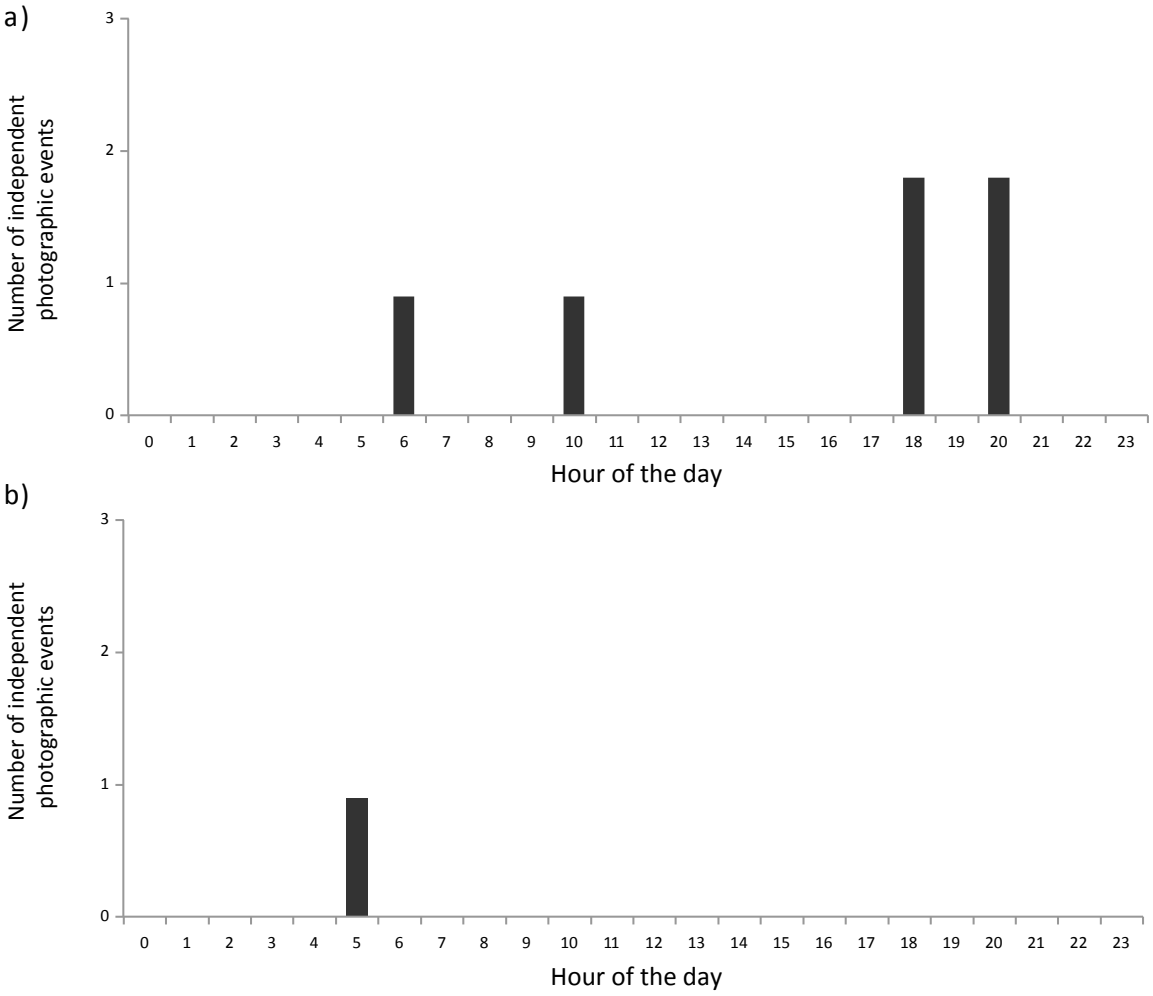
**Table 46** Naïve and modelled occupancy and detection probability estimates for the honey badger in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.21 | 1.00 (±0.07)* | 0.03 (±0.01) |
| Boni forest | 0.08 | 0.08 (±0.00)* | 0.01 (±0.01) |
| Dodori NR | 0.10 | 1.00 (±0.14)* | 0.02 (±0.01) |
| Arabuko-Sokoke Forest | 0.05 | 0.05 (±0.00)* | 0.01 (±0.01) |

* interpret with caution; limited sample data.

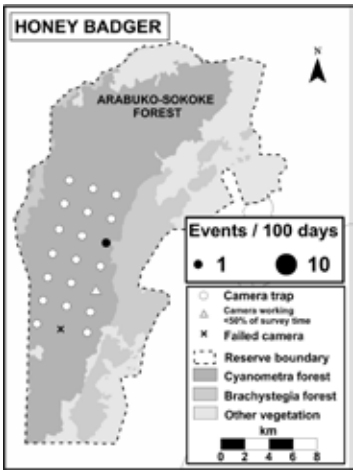
**Behaviour**: If undisturbed, honey badger are known to be active during both day and night but in areas with human presence they tend to become nocturnal. The small number of records in this study show both day and night time activity (Figure 45).

**Figure 45** Temporal distribution of honey badger records in (a) the Boni-Dodori forest system and (b) the Arabuko-Sokoke forest through the 24 hour cycle.



## Summary

The honey badger was recorded at low frequency in all forest reserves although at only one location in Arabuko-Sokoke *Cynometra forest* (Figure 46). The Aweer people in the northern coastal forests are known for their ability to find honey through whistled communications with black-throated honeyguides (*Indicator indicator*). It would be of interest to understand the local community attitude to honey badger in relation to wild honey harvesting.



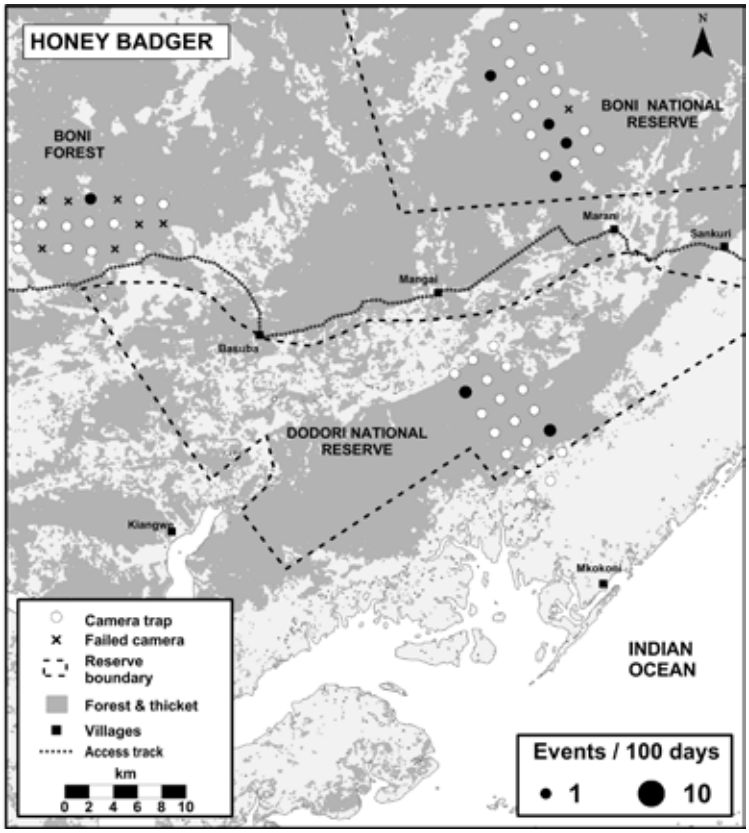




**Figure 46** Honey badger distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

## 22 *Helogale parvula*

(Sundevall, 1847)

**Common names**

Common dwarf mongoose (English); Kitafe (Swahili).

**Species description**

The common dwarf mongoose is 30 cm long with a slender body, pointed head, short legs and a long tail. They are sociable and often move in large groups. It's small size distinguishes it from all other mongooses except the very similar Somali dwarf mongoose (*Helogale hirtula*). It is not possible to discern between these two species from black and white camera-trap photographs. On distributional / habitat grounds it is considered more likely that the animals recorded are common dwarf mongoose, but both species are reported in close proximity in the area and it would be valuable to confirm this identification in future.

**Global conservation status**

IUCN Red List Status: Least Concern.

**Legal status**

CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: Not Listed.
African Convention on the Conservation of Nature and Natural Resources: Not Listed.

***Camera-trap survey results***

**Relative abundance:** The dwarf mongoose was infrequently recorded with a maximum of five events in the Boni forest camera grid (Table 47).

**Table 47** Dwarf mongoose trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 3 | 1670 | 0.18 (±0.11) |
| Boni forest | 5 | 1026 | 0.50 (±0.22) |
| Dodori NR | 2 | 1087 | 0.18 (±0.12) |
| Arabuko-Sokoke Forest | 1 | 2049 | 0.05 (±0.05) |

**Occupancy**: The dwarf mongoose was detected in all the camera grids with highest occupancy in the Boni forest camera grid and lowest occupancy in the Arabuko-Sokoke Forest camera grid (Table 48).

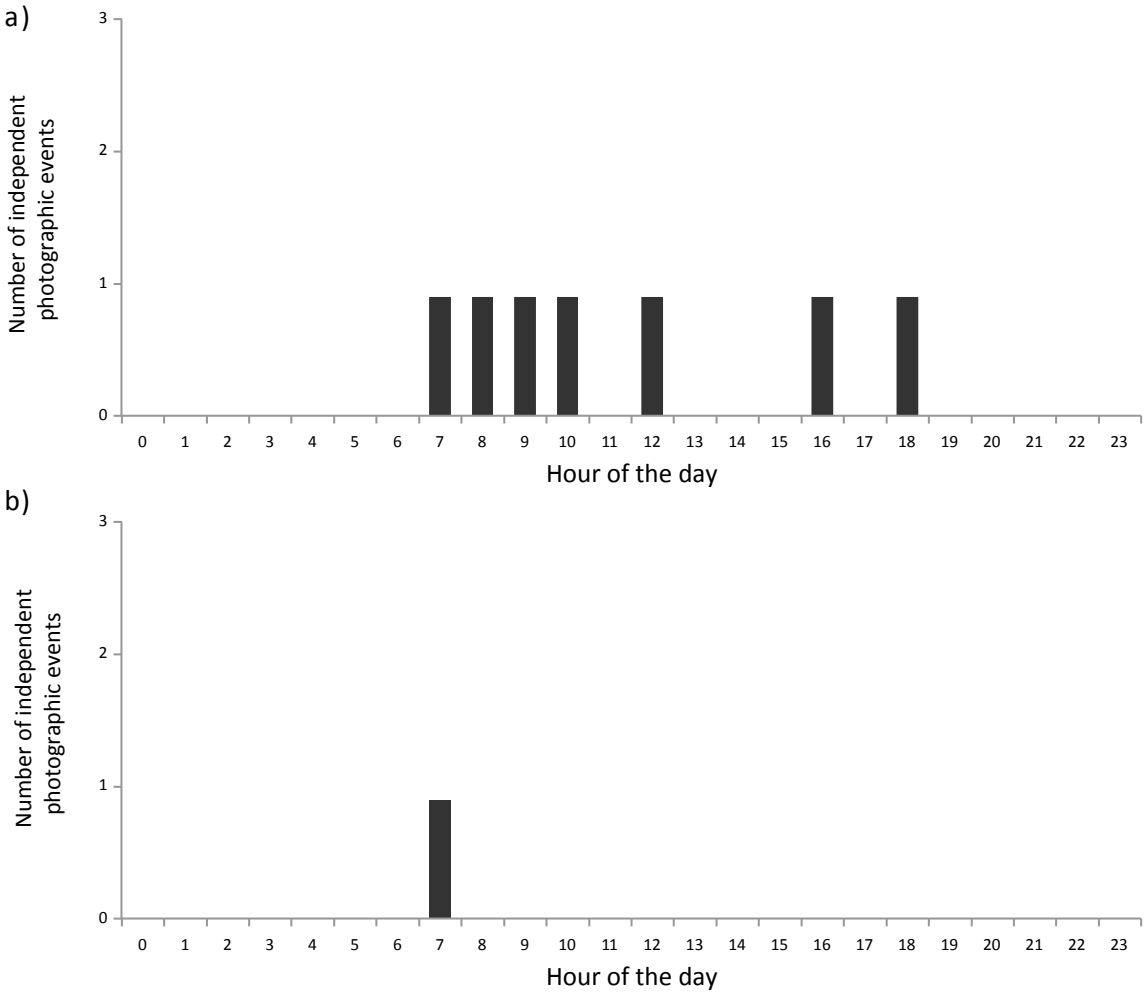
**Table 48** Naïve and modelled occupancy and detection probability estimates for the dwarf mongoose in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.16 | 1.00 (±0.11)* | 0.02 (±0.01) |
| Boni forest | 0.31 | 0.72 (±0.59)* | 0.07 (±0.07) |
| Dodori NR | 0.10 | 1.00 (±0.14)* | 0.02 (±0.01) |
| Arabuko-Sokoke Forest | 0.05 | 0.05 (±0.00)* | 0.01 (±0.01) |

* interpret with caution; limited sample data.

**Behaviour**: Dwarf mongoose were diurnal with events occurring between 07:00 and 19:00 (Figure 47).

**Figure 47** Temporal distribution of dwarf mongoose records in (a) the Boni-Dodori forest system and (b) the Arabuko-Sokoke forest through the 24 hour cycle.



## Summary

Dwarf mongooses were recorded in all four forest sites at a few camera locations (Figure 48). The low trapping rates may in part reflect the fact that this species is much more associated with light woodland and bush habitats rather than forest and thicket. Confirmation of the exact species identification by inspection of live specimens is recommended, especially of the form found north of the Tana River.

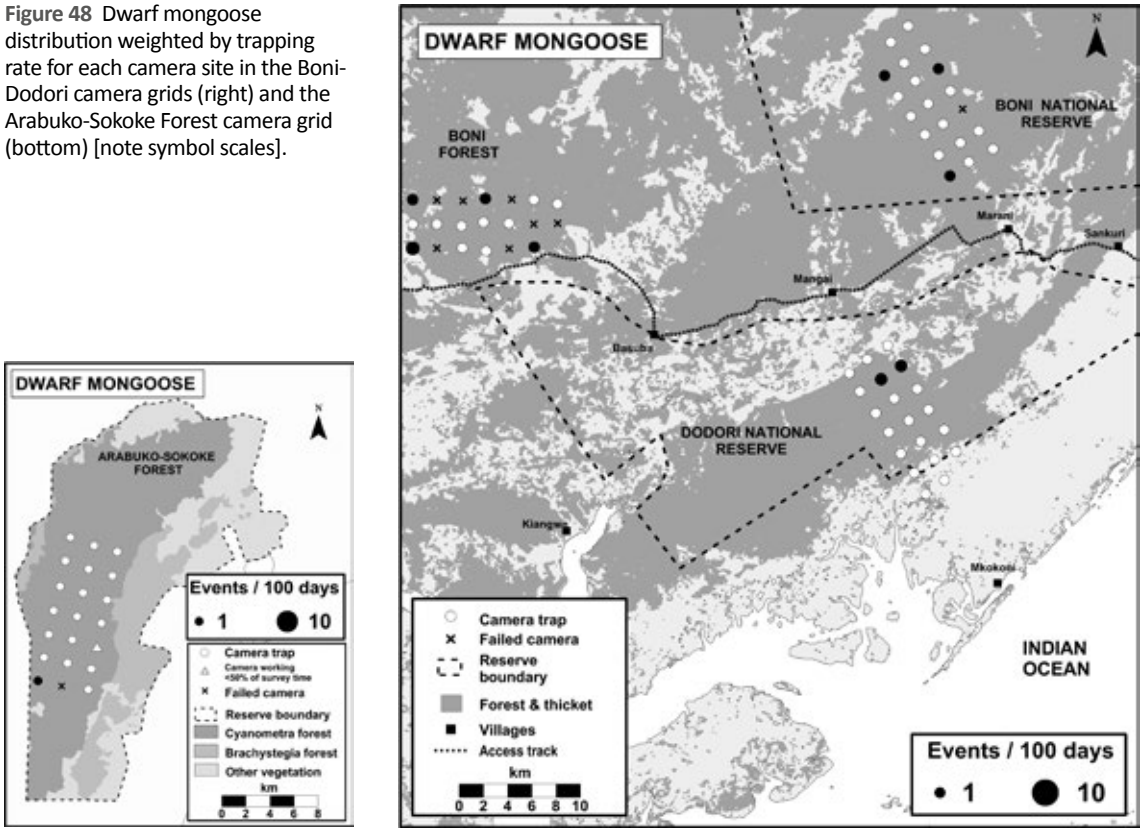



**Figure 48** Dwarf mongoose distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

## 23 *Atilax paludinosus*
(Cuvier, 1829)

**Common names**
Marsh mongoose (English); Nguchiro wa maji (Swahili).

**Species description**
The marsh mongoose is one of the largest of the mongoose family, growing up to 100 cm from nose to tail. It has thick dark brown fur and black tipped guard hairs which give its coat a course appearance. The marsh mongoose is solitary and, as the name suggests, favours permanent freshwater habitats. Its large size, dark colouration and heavy frame distinguish it from other species of mongoose.

**Global conservation status**
IUCN Red List Status: Least Concern.

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: Not Listed.
African Convention on the Conservation of Nature and Natural Resources: Not Listed.

***Camera-trap survey results***

**Relative abundance:** The species was only recorded once in the Dodori camera grid (Table 49).

**Table 49** Marsh mongoose trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 0 | 1670 | - |
| Boni forest | 0 | 1026 | - |
| Dodori NR | 1 | 1087 | 0.09 (±0.09) |
| Arabuko-Sokoke Forest | 0 | 2049 | - |

**Occupancy**: The marsh mongoose was detected only once in the Dodori camera grid (Table 50).

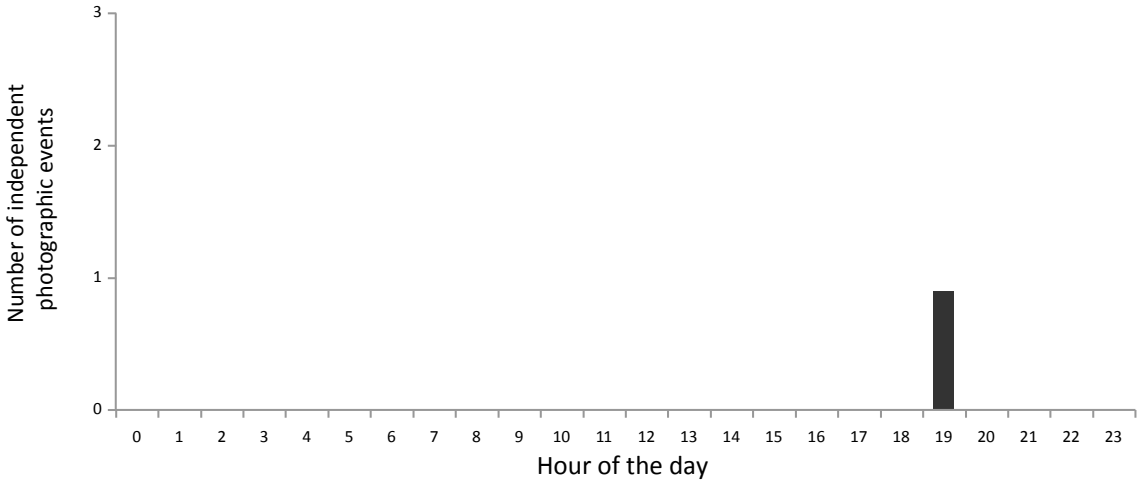
**Table 50** Naïve and modelled occupancy estimates and detection probability estimates for the marsh mongoose in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | N/A | N/A | N/A |
| Boni forest | N/A | N/A | N/A |
| Dodori NR | 0.05 | 0.05 (±0.00)* | 0.01 (±0.01) |
| Arabuko-Sokoke Forest | N/A | N/A | N/A |

* interpret with caution; limited sample data.

**Behaviour**: The only record of the marsh mongoose occurred at 19:00 (Figure 49).

**Figure 49** Temporal distribution of marsh mongoose records in the Boni-Dodori forest system through the 24 hour cycle.



## Summary

Marsh mongoose inhabit river courses and lake shore areas. The only record of this species in the survey came from a camera close to the waterholes associated with the Dodori River in Dodori NR. The same camera produced the only record of another semi-aquatic species, the Hippopotamus, further indicating proximity of aquatic habitat conditions at this location (Figure 50).

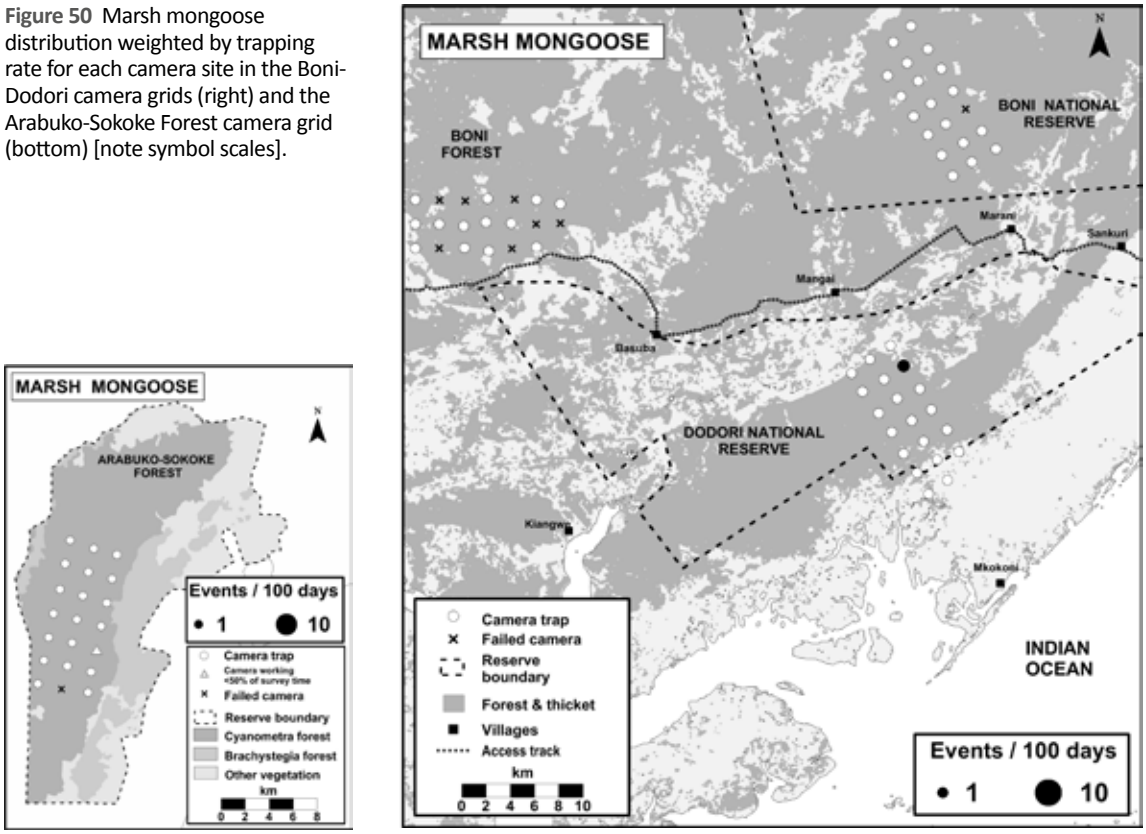



**Figure 50** Marsh mongoose distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

## 24 *Herpestes sanguineus*
(Rüppell, 1835)

**Common names**
Slender mongoose, Black-tailed mongoose, Black-tipped mongoose (English).

**Species description**
The slender mongoose is 26-34 cm long with a 23-32 cm tail. Its body is elongated and the long tail ends in a tuft of black fur which is often held, up or curled back towards the body. In camera-trap images the slender mongoose can be distinguished by its low-slung body, light build, and long tail with black terminal tuft.

**Global conservation status**
IUCN Red List Status: Least Concern.

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: Not Listed.
African Convention on the Conservation of Nature and Natural Resources: Not Listed.

***Camera-trap survey results***

**Relative abundance:** The slender mongoose was recorded on six occasions at different camera sites; one site in Dodori NR and five in Boni forest (Table 51).

**Table 51** Slender mongoose trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 0 | 1670 | - |
| Boni forest | 5 | 1026 | 0.50 (±0.22) |
| Dodori NR | 1 | 1087 | 0.09 (±0.09) |
| Arabuko-Sokoke Forest | 0 | 2049 | - |

**Occupancy**: The slender mongoose was only detected in the Dodori NR and Boni forest camera grids (Table 52).

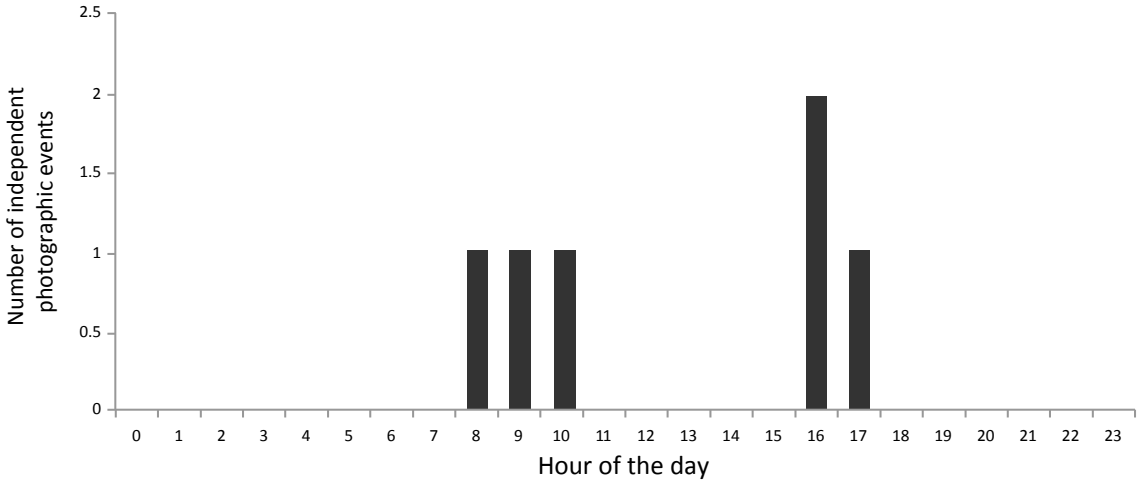
**Table 52** Naïve and modelled occupancy and detection probability estimates for the slender mongoose in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | N/A | N/A | N/A |
| Boni forest | 0.08 | 0.08 (±0.00)* | 0.01 (±0.01) |
| Dodori NR | 0.05 | 0.05 (±0.00)* | 0.01 (±0.01) |
| Arabuko-Sokoke Forest | N/A | N/A | N/A |

* interpret with caution; limited sample data.

**Behaviour**: All six slender mongoose events occurred during daylight (Figure 51).

**Figure 51** Temporal distribution of slender mongoose records in the Boni-Dodori forest system through the 24 hour cycle.



## Summary

The slender mongoose is one of the most widely occurring mongooses in Africa. It is found in a wide range of habitats, and is not specifically associated with forest and thicket habitat. It was only recorded on six occasions at separate camera sites in Dodori NR and Boni forest (Figure 52). Although previously reported from Arabuko-Sokoke Forest (Kanga 2002), none were detected there in this survey. It seems likely that although tolerant of a wide range of habitats, the widespread presence of the Sokoke bushytailed mongoose, a coastal forest specialist, in the northern forest system may inhibit the numbers of other mongoose species.

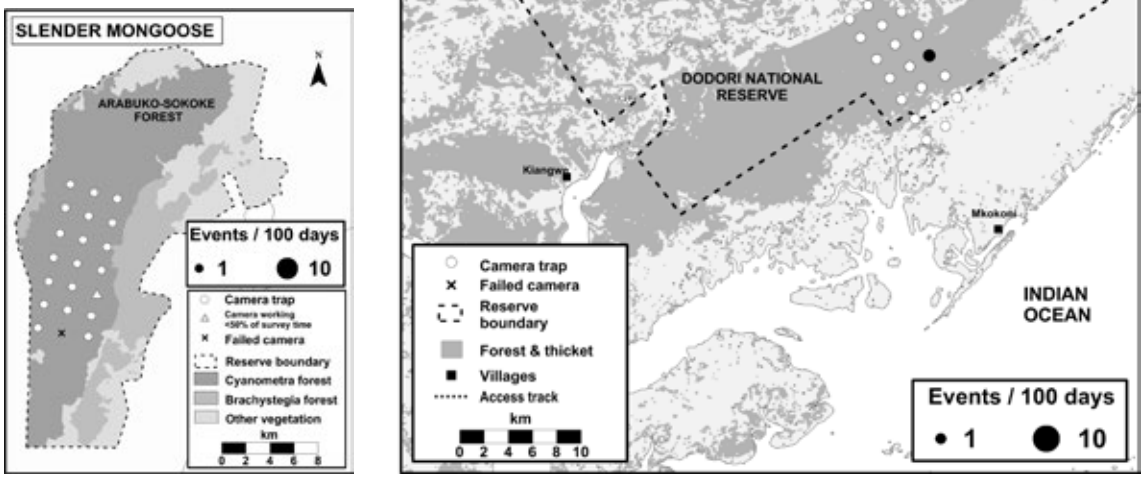



**Figure 52** Slender mongoose distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

## 25 *Ichneumia albicauda*
(Cuvier, 1829)

**Common names**
White-tailed mongoose (English); Karambago (Swahili).

**Species description**
With a body 47-71 cm long and a 35-50 cm tail the white-tailed mongoose is the largest of the mongoose family. The pale body colouration with dark legs (see above) is superficially reminiscent of the pattern on the Sokoke bushy-tailed mongoose in camera-trap images. The white-tailed mongoose is recognised by its longer legs, arched back and long typically tapering tail (usually but not necessarily white), giving it a distinctive body shape.

**Global conservation status**
IUCN Red List Status: Least Concern.

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: Not Listed.
African Convention on the Conservation of Nature and Natural Resources: Not Listed.

***Camera-trap survey results***

**Relative abundance:** The white-tailed mongoose, another widespread species associated with a range of habitats, was recorded twice in the Arabuko-Sokoke Forest and once in the Boni-Dodori forest system (Table 53).

**Table 53** White-tailed mongoose trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 1 | 1670 | 0.06 (±0.06) |
| Boni forest | 0 | 1026 | - |
| Dodori NR | 0 | 1087 | - |
| Arabuko-Sokoke Forest | 2 | 2049 | 0.10 (±0.09) |

**Occupancy**: The white-tailed mongoose was detected in only one camera station in Boni NR and in the Arabuko-Sokoke Forest camera grid in only two out of the 18 camera stations (Table 54).

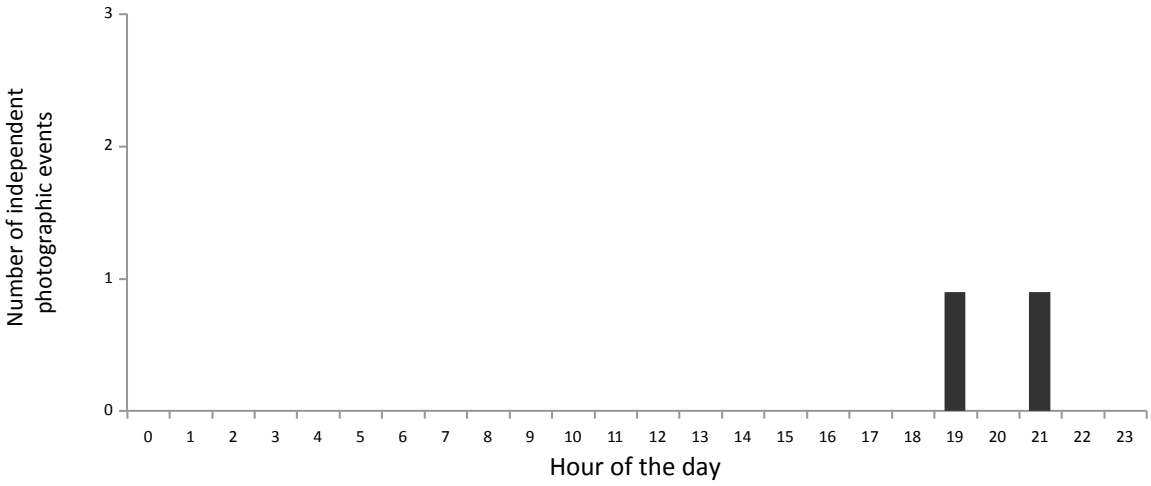
**Table 54** Naïve and modelled occupancy and detection probability estimates for the white-tailed mongoose in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.053 | 0.053 (±0.0)* | 0.006 (±0.007) |
| Boni forest | N/A | N/A | N/A |
| Dodori NR | N/A | N/A | N/A |
| Arabuko-Sokoke Forest | 0.11 | 1.00 (±0.20)* | 0.01 (±0.01) |

* interpret with caution; limited sample data.

**Behaviour**: Both white-tailed mongoose events occurred in the evening (Figure 53).

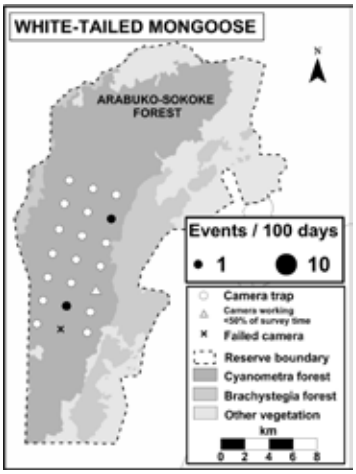
**Figure 53** Temporal distribution of whiite-tailed mongoose records in the Arabuko-Sokoke Forest through the 24 hour cycle.

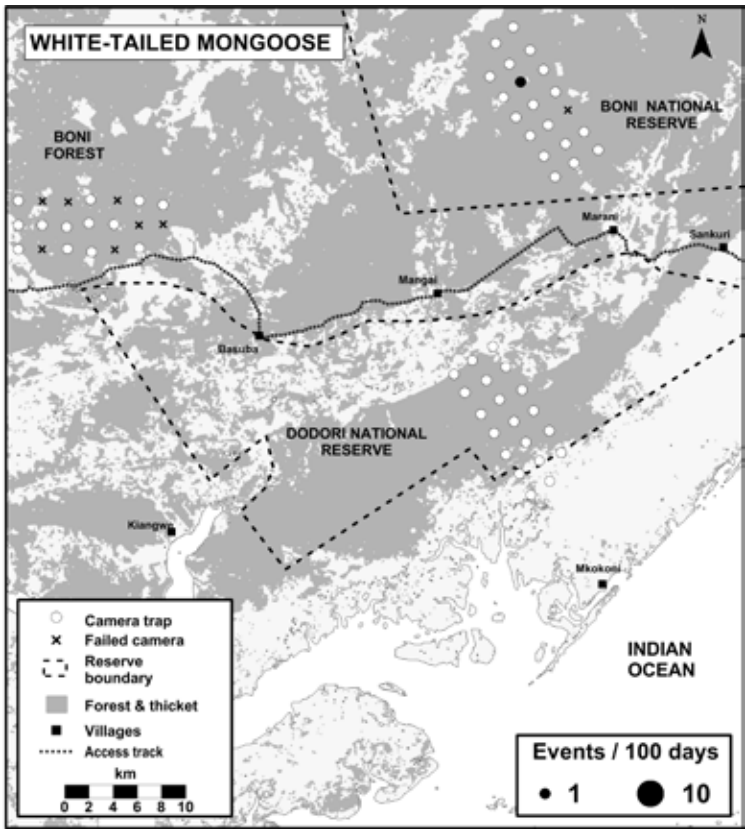


## Summary

The white-tailed mongoose was only recorded on two occasions in the Arabuko-Sokoke *Cynometra* forest and once in Boni NR (Figure 54). As with several other mongoose species using a wide range of habitats, the camera-trap sample zones are not focused on preferred habitat for this species. The presence of the Sokoke bushy-tailed mongoose, a forest specialist relative, at much higher frequency is likely to be a factor, though a detailed study of the forests small carnivore community would be needed to confirm and explain these differences.

**Figure 54** White-tailed mongoose distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].



## 26 *Bdeogale omnivora*

(Heller, 1913)

**Common names**

Sokoke bushy-tailed mongoose, Sokoke dog mongoose, (English); Sokoke (Swahili).

**Species description**

The Sokoke bushy-tailed mongoose was originally classified as a subspecies of the bushy-tailed mongoose (*B. crassicuda)*, but more recently has also been treated as a full species (Taylor 2013). It is 40-50 cm long and has dense, cream-coloured under fur contributing to a pale body colour with darker legs and tail. It is shorter legged than the white-tailed mongoose and the dark tail is of more even thickness along its length, distinguishing it from dark morphs of white-tailed mongoose.

**Global conservation status**

IUCN Red List Status: Vulnerable.

**Legal status**

CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: Not Listed.
African Convention on the Conservation of Nature and Natural Resources: Not Listed.

***Camera-trap survey results***

**Relative abundance:** The Sokoke bushy-tailed mongoose is the most frequently recorded of the five species of mongoose in the camera grids. It was only recorded in the Boni-Dodori forest system with the forests north of the Boni-Dodori corridor particularly important. It is known to occur in the Arabuko-Sokoke Forest, as its' name suggests, but despite greater sampling effort in this area no individuals were detected (Table 55).

**Table 55** Sokoke bushy-tailed mongoose trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 55 | 1670 | 3.24 (±0.45) |
| Boni forest | 45 | 1026 | 4.30 (±0.66) |
| Dodori NR | 17 | 1087 | 1.49 (±0.38) |
| Arabuko-Sokoke Forest | 0 | 2049 | - |

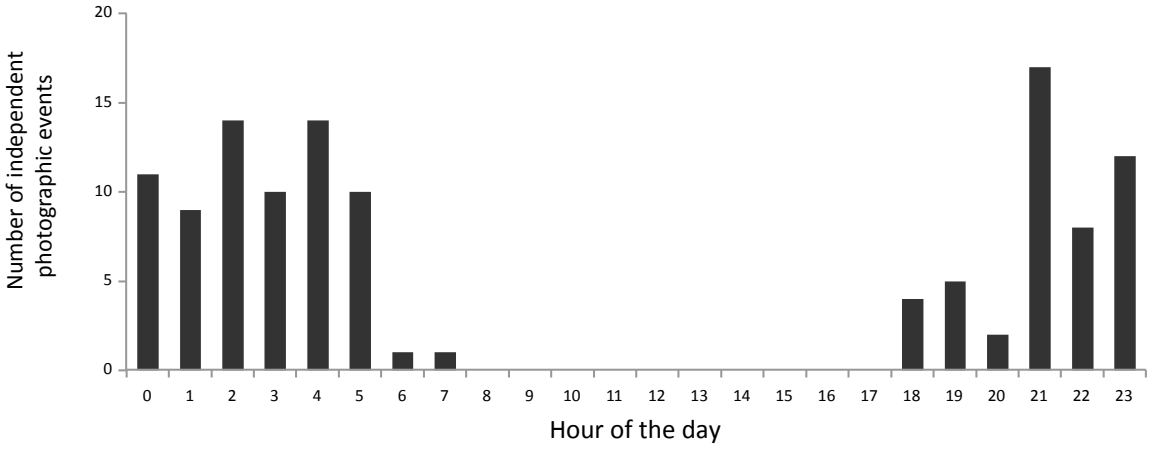
**Occupancy**: The Sokoke bushy-tailed mongoose was only detected in the Boni-Dodori camera grids. Occupancy estimates were higher in the two Boni forest blocks than at Dodori Forest (Table 56).

**Table 56** Naïve and modelled occupancy and detection probability estimates for the Sokoke bushy-tailed mongoose in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.74 | 0.79 (±0.11) | 0.31 (±0.05) |
| Boni forest | 0.62 | 0.64 (±0.14) | 0.37 (±0.07) |
| Dodori NR | 0.35 | 0.46 (±0.16) | 0.24 (±0.09) |
| Arabuko-Sokoke Forest | N/A | N/A | N/A |

**Behaviour**: Sokoke bushy-tailed mongoose were nocturnal with no events occurring between 08:00 and 18:00 (Figure 55).

**Figure 55** Temporal distribution of Sokoke bushy-tailed mongoose records in the Boni-Dodori forest system over a 24 hour period.



## Summary

The presence of the Sokoke bushy-tailed mongoose in the Boni-Dodori forest system was previously known from museum specimens. The new information from the camera-trap survey is that the Boni-Dodori forest system is likely to act as a very significant population centre for the species (Figure 56). The Arabuko-Sokoke Forest is also considered an important site for the species, but no individuals were detected in the Cynometra forest sampled by the camera grid despite significant survey effort. Further surveys in the Brachystegia and mixed forests are required to confirm the status of the Sokoke bushy-tailed mongoose in this area. Described as 'nocturnal and solitary' it is notable that almost 10% of camera-trap events recorded pairs foraging together.

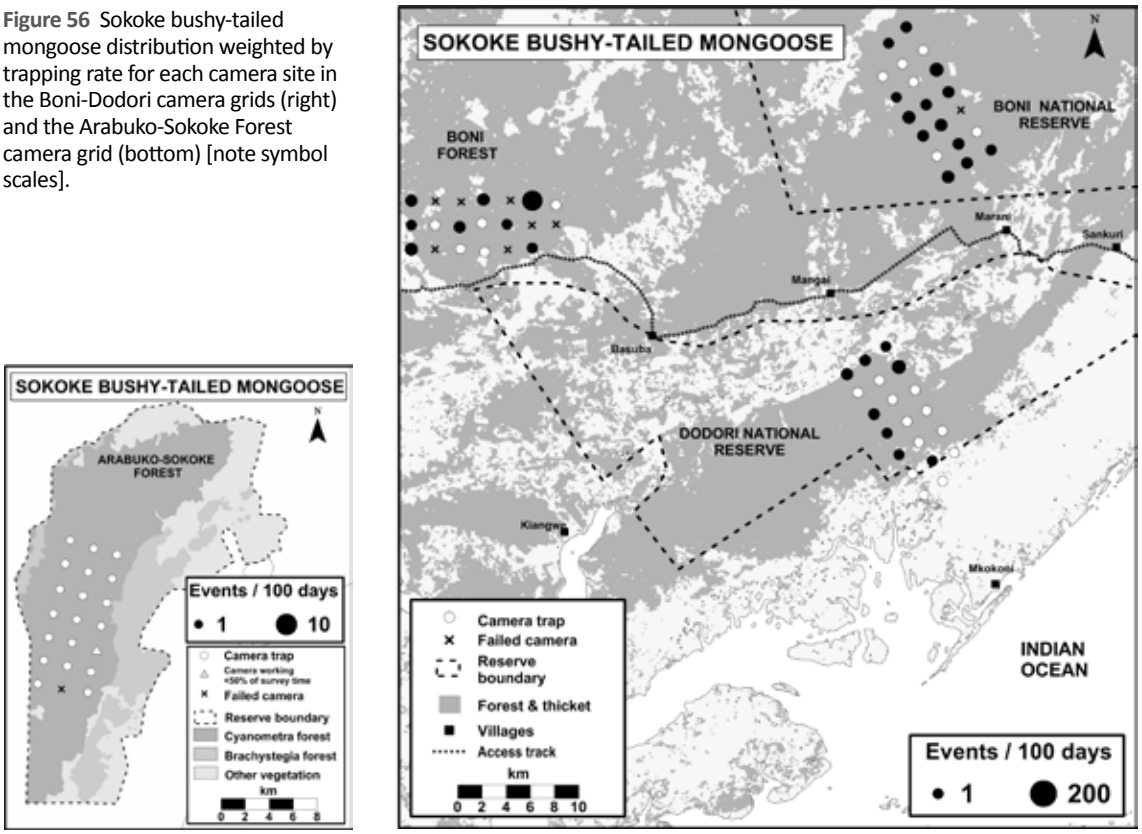



**Figure 56** Sokoke bushy-tailed mongoose distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

# Afrotheria

The afrotheria are a group of mammals that have evolved into astonishingly diverse and dissimilar families and species having shared a very distant common ancestor (Kuntner et al. 2011). They are now found primarily in Africa. The coastal forests of Kenya host at least five species, each charismatic in varying ways.

Afrotheria are most prominently represented in the study area by sengis (elephant-shrews). Most notable is the golden-rumped sengi, which is strictly endemic to this region of Kenya, so wholly dependent on the Kenyan coastal forests. The documentation of distribution and recording frequency of a new form of giant sengi, probably closely related to golden-rumped, in the northern forests is one of the notable outputs of this report. In addition to the giant sengis, two smaller 'soft-furred' sengi species are present, and although frequently photographed, could not be reliably distinguished in imagery obtained. Two other Afrotheria recorded are the aard-vark and African elephant. Both are notable for making unusually obvious ecological impacts through their normal behaviour, and elephants in particular play a significant economic role at national / international level.

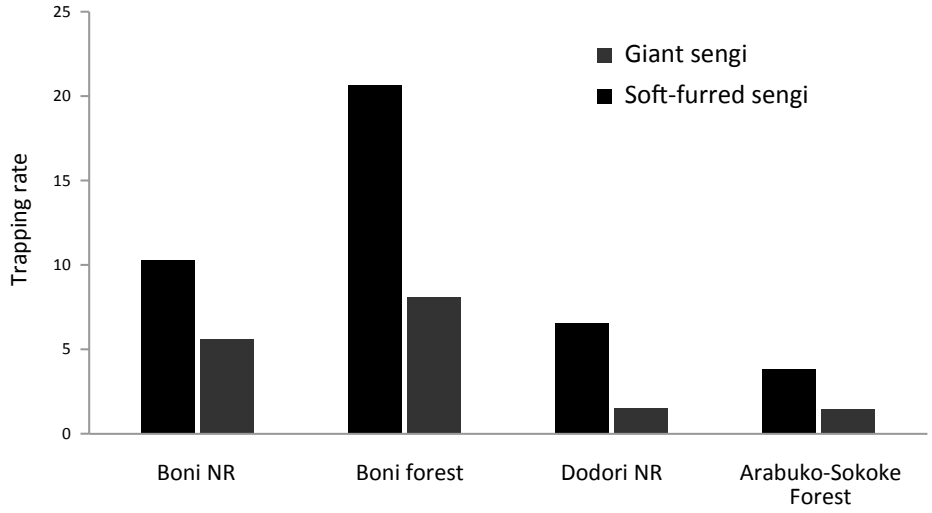
## Sengis or elephant shrews

There are currently considered to be 17 species of sengi or elephant shrews from a single family (Macroscelididae), all endemic to Africa. The group is divided into two well-defined sub-families: the soft-furred sengis (Macroscelidinae) with three genera and 13 species, and the giant sengis (Rhynchocyoninae) with a single genus (*Rhynchocyon*) and four species. The montane and coastal forests of Kenya and Tanzania are the centre of diversity for *Rhynchocyon* with Kenya harbouring two species (the black-and-rufous sengi (*R.petersi*) and the endemic golden-rumped elephant shrew (*R. chrysopygus*)). Tanzania has three species (the chequered sengi *R. cirnei*, the endemic grey-faced sengi (*R.udzungwensis*) and (*R. petersi*)).

The four camera grids detected both the soft-furred sengis and giant sengis. Two soft-furred sengi species are known to occur in the Boni-Dodori forests. The ranges of the rufous sengi (*Elephantulus rufescens*) and four-toed sengi (*Petrodromus tetradactylus*) were recently extended following a preliminary survey (Andanje et al. 2010). However, it was difficult to determine the species from the black and white images in this study. Therefore the data for the soft-furred sengis are grouped for analyses. The giant sengi detected in the northern camera grids may be a new species. It shows no sign of the distinctive pale rump of the golden-rumped elephant shrew found in the Arabuko-Sokoke forest. Further investigation into its taxonomic status is in progress.

Both sub-families were detected in all four camera grids. The soft-furred sengis occurred at the highest trapping rate in the Boni forest camera grid followed by Boni NR. Trapping rate for the *Rhynchocyon sp.* was also highest in the Boni forest camera grid (Figure 57).

**Figure 57** Trapping rates for the soft-furred and giant sengi recorded at each of the four camera sampling sites.



## 27 *Loxodonta africana*

(Blumenbach, 1797)

**Common names**
African elephant (English); Ndovu, Tembo (Swahili).

**Species description**
The African elephant is the largest of the African land mammals. Like buffalo, camera-trap images commonly only show part of the animal as cameras are set to monitor smaller species.

**Global conservation status**
IUCN Red List Status: Vulnerable.

**Legal status**
CITES: Appendix I.
Kenya Wildlife (Conservation and Management) Act: First schedule.
African Convention on the Conservation of Nature and Natural Resources: Class B.

***Camera-trap survey results***

**Relative abundance:** The African elephant was only recorded at low frequency (trapping rate 0.12 to 1.12) in the Boni-Dodori camera grids (Table 57).

**Table 57** African elephant trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 2 | 1670 | 0.12 (±0.08) |
| Boni forest | 12 | 1026 | 1.12 (±0.40) |
| Dodori NR | 3 | 1087 | 0.26 (±0.15) |
| Arabuko-Sokoke Forest | 0 | 2049 | - |

**Occupancy**: Although known to occur in the area, African elephant was not detected in the Arabuko-Sokoke camera grid. The species had a low occupancy in Boni-Dodori camera grids (Table 58).

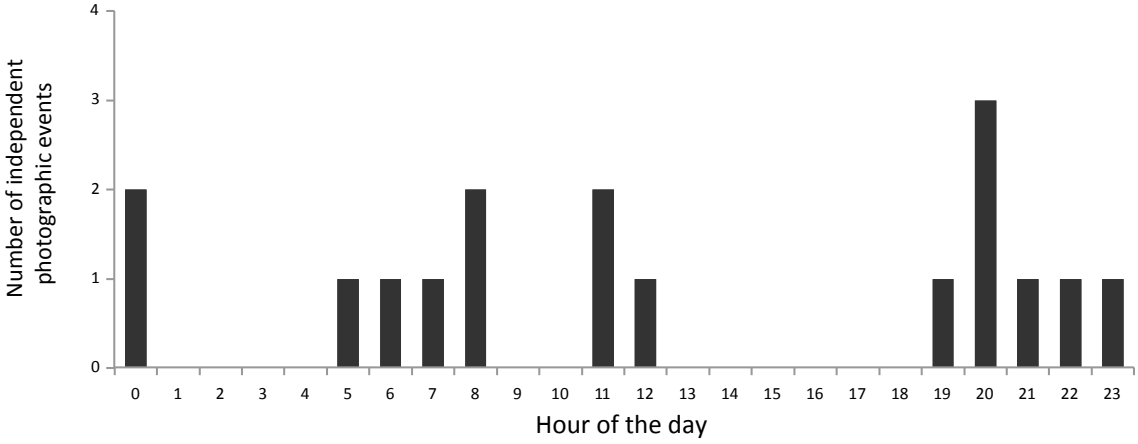
**Table 58** Naïve and modelled occupancy and detection probability estimates for the African elephant in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.11 | 1.00 (±0.09)* | 0.01 (±0.01) |
| Boni forest | 0.23 | 0.24 (±0.12) | 0.38 (±0.11) |
| Dodori NR | 0.15 | 1.00 (±0.12)* | 0.03 (±0.02) |
| Arabuko-Sokoke Forest | N/A | N/A | N/A |

* interpret with caution; limited sample data.

**Behaviour**: African elephant were active both during the day and at night (Figure 58).

**Figure 58** Temporal distribution of African elephant records in the Boni-Dodori forest system over a 24 hour period.



## Summary

Although known to use the Arabuko-Sokoke Forest, where a dung count survey estimated 184 African elephants in 2002, none were recorded there in this survey (Figure 59). A population estimate of 50 elephants was obtained for the Boni-Dodori forest system in 2000, but the data quality was indicated to be low (Litoroh et al. 2012). The largest group detected by camera-trapping numbered 26 individuals, including at least five young, who passed consecutively in front of camera L4 in Boni forest on the evening of 9th August 2010. For elephants it would be of interest to combine future camera-trapping in these sites with simultaneous sight and sign surveys of elephant.

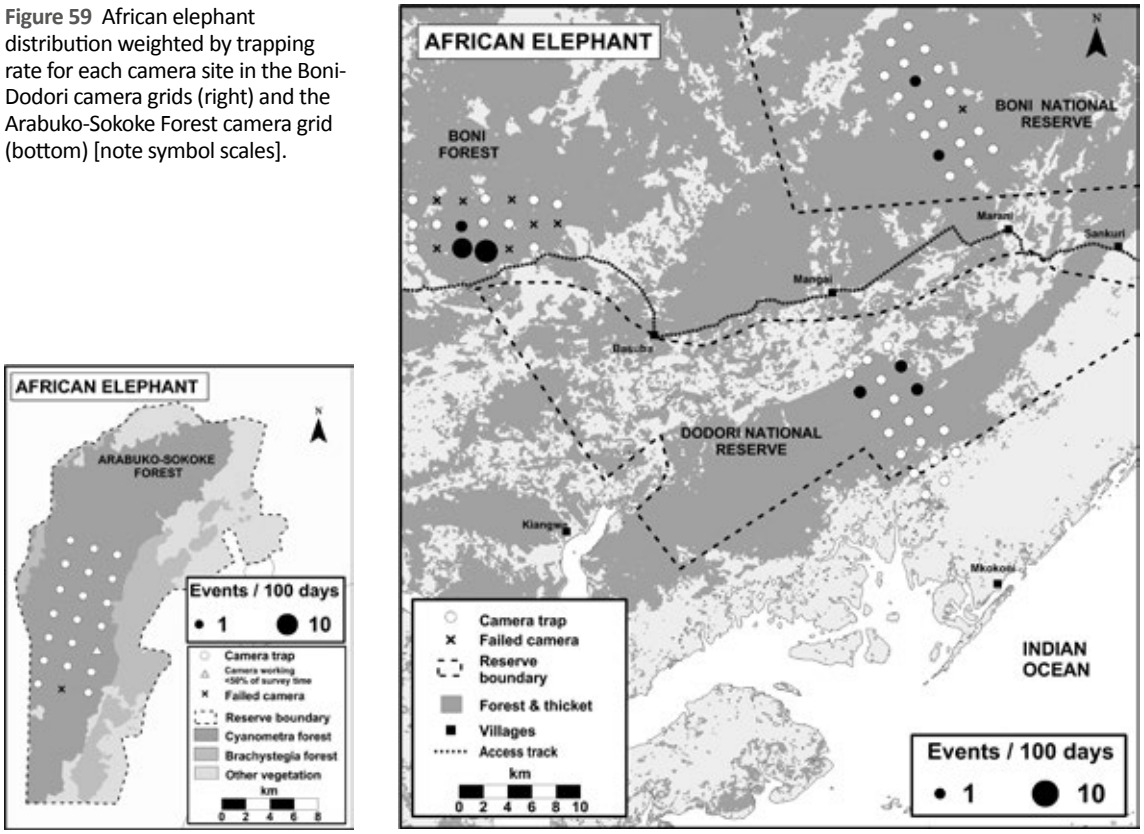



**Figure 59** African elephant distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

## 28 *Orycteropus afer*
(Pallas, 1766)

**Common names**
Aard-vark (English)

**Species description**
The arched body shape, stout limbs and tail, elongated face and long ears of the aard-vark make it highly distinctive from almost any angle of view. They are notable for a very wide continental distribution and a correspondingly wide range of habitat tolerance, from forest to grasslands and desert margins.

**Global conservation status**
IUCN Red List: Least Concern.

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: Third Schedule.
African Convention on the Conservation of Nature and Natural Resources: Class B.

***Camera-trap survey results***

**Relative abundance:** Aard-varks were recorded on 18 occasions from all four camera grids. Trapping rates do not vary greatly, but the lowest trapping rate was recorded at Arabuko-Sokoke Forest (Table 59). They were the least frequently recorded of the large species likely to make regular use of forest-thicket habitat, although they occurred at higher rates than blue duiker in the Boni-Dodori forest system.

**Table 59** Aard-vark trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 7 | 1670 | 0.42 (±0.15) |
| Boni forest | 5 | 1026 | 0.50 (±0.22) |
| Dodori NR | 4 | 1087 | 0.35 (±0.17) |
| Arabuko-Sokoke Forest | 2 | 2049 | 0.10 (±0.07) |

**Occupancy**: Aard-vark was photographed at between 10% (Arabuko-Sokoke Forest) and 32% (Boni NR) of the camera stations (Table 60).

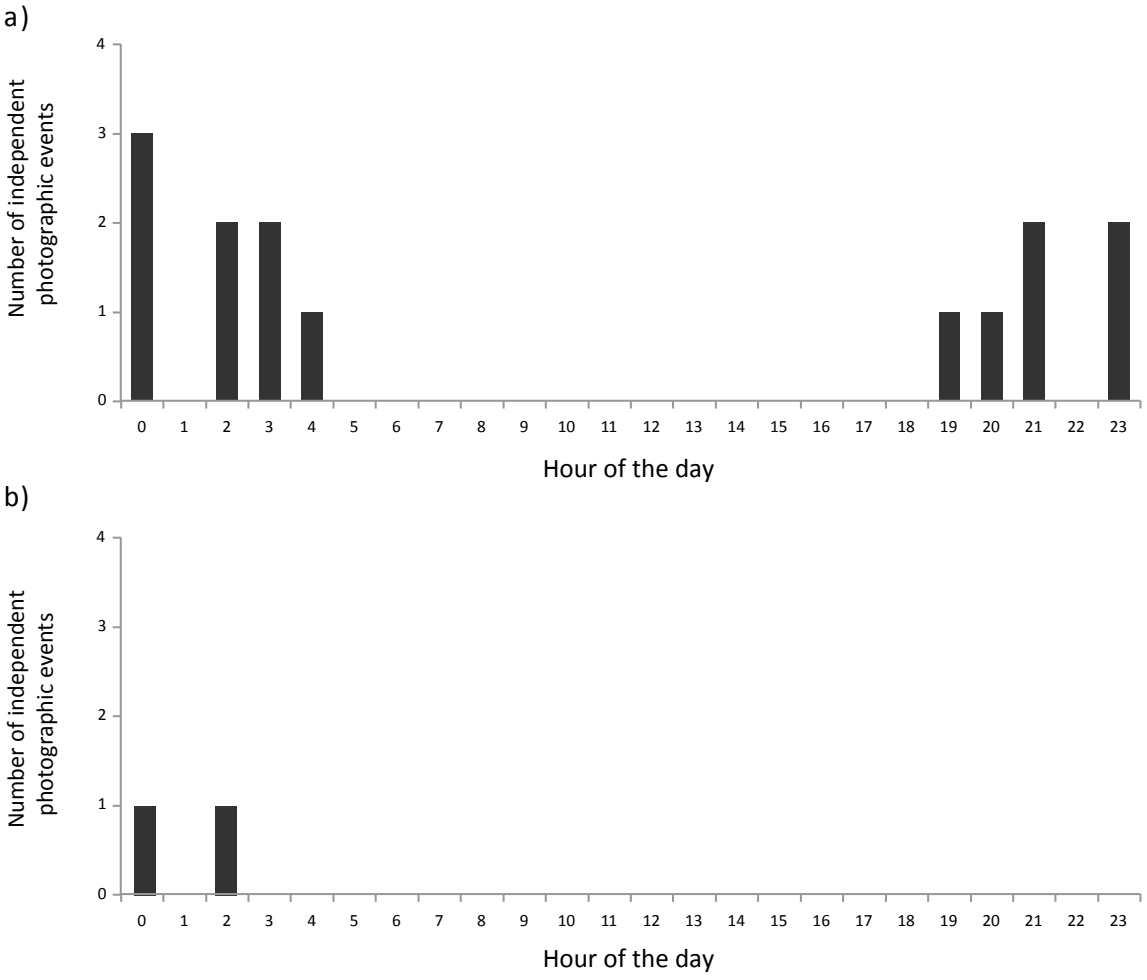
**Table 60** Naïve and modelled occupancy and detection probability estimates for the Aard-vark in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.32 | 0.99 (±0.23)* | 0.05 (±0.02) |
| Boni forest | 0.31 | 1.00 (±0.05)* | 0.04 (±0.02) |
| Dodori NR | 0.10 | 0.14 (±0.11)* | 0.21 (±0.17) |
| Arabuko-Sokoke Forest | 0.05 | 0.05 (±0.00)* | 0.01 (±0.01) |

* interpret with caution; limited sample data.

**Behaviour**: All photographs took place from 19:00 to 05:00 as expected for the well-known nocturnal habit of this species (Figure 60).

**Figure 60** Temporal distribution of aard-vark records in (a) the Boni-Dodori forest system and (b) the Arabuko-Sokoke Forest through the 24 hour cycle.



## Summary

This study has confirmed the consistent presence of aard-vark at low levels in all four study areas (Figure 61). Both trapping rate and naïve occupancy are lowest at Arabuko-Sokoke Forest, suggesting they may be comparatively less frequent in Arabuko-Sokoke Forest, a pattern observed in nearly all other large mammal species. The presence of aard-vark is important both for its unusual phylogenetic status and ecological role. The aard-vark's extensive tunnelling and digging in termite mounds is believed to provide feeding opportunities and living space for many indirectly associated species. By creating these niches, the aard-vark contributes directly to forest diversity (Cilliers 2002).

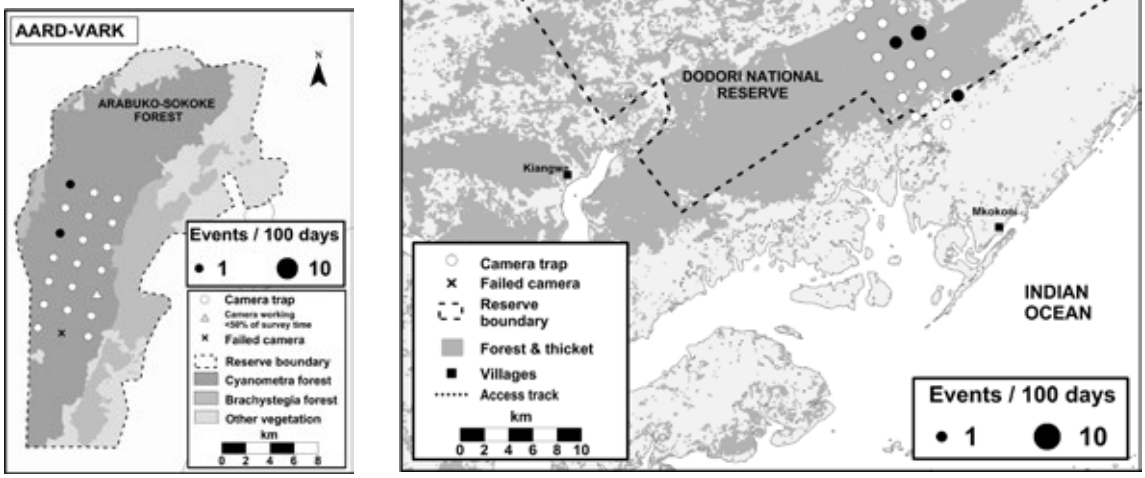



**Figure 61** Aard-vark distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

## 29 *Petrodromus tetradactylus* (Peters, 1846) and *Elephantulus rufescens* (Peters, 1878)

**Common names**
Petrodromus tetradactylus - Four-toed sengi, four-toed elephant shrew (English), Isanje (Swahili).
Elephantulus rufescens - Rufous sengi, rufous elephant shrew (English).

**Species description**
The four-toed sengi has a 16-22 cm long body with a 13-18 cm tail. The rufous sengi is around 12 cm long. Despite the size difference it is very difficult to differentiate between the two species in black and white camera-trap images. To avoid false estimates these two representatives of the 'soft-furred' sengi group have been combined as a single category 'small sengis'.

**Global conservation status**
IUCN Red List Status: Least Concern.

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: Not Listed.
African Convention on the Conservation of Nature and Natural Resources: Not Listed.

***Camera-trap survey results***

**Relative abundance:** The soft-furred sengis appear to be considerably more abundant in the more inland forests north of the Boni-Dodori corridor (trapping rate = 14.3) than south of the corridor (trapping rate = 6.5). Soft-furred sengis were found at a lower frequency in the Arabuko-Sokoke Cynometra forest (trapping rate = 3.8) (Table 61).

**Table 61** Soft-furred trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 173 | 1670 | 10.33 (±0.96) |
| Boni forest | 213 | 1026 | 20.68 (±1.82) |
| Dodori NR | 75 | 1087 | 6.55 (±0.69) |
| Arabuko-Sokoke Forest | 76 | 2049 | 3.8 (±0.39) |

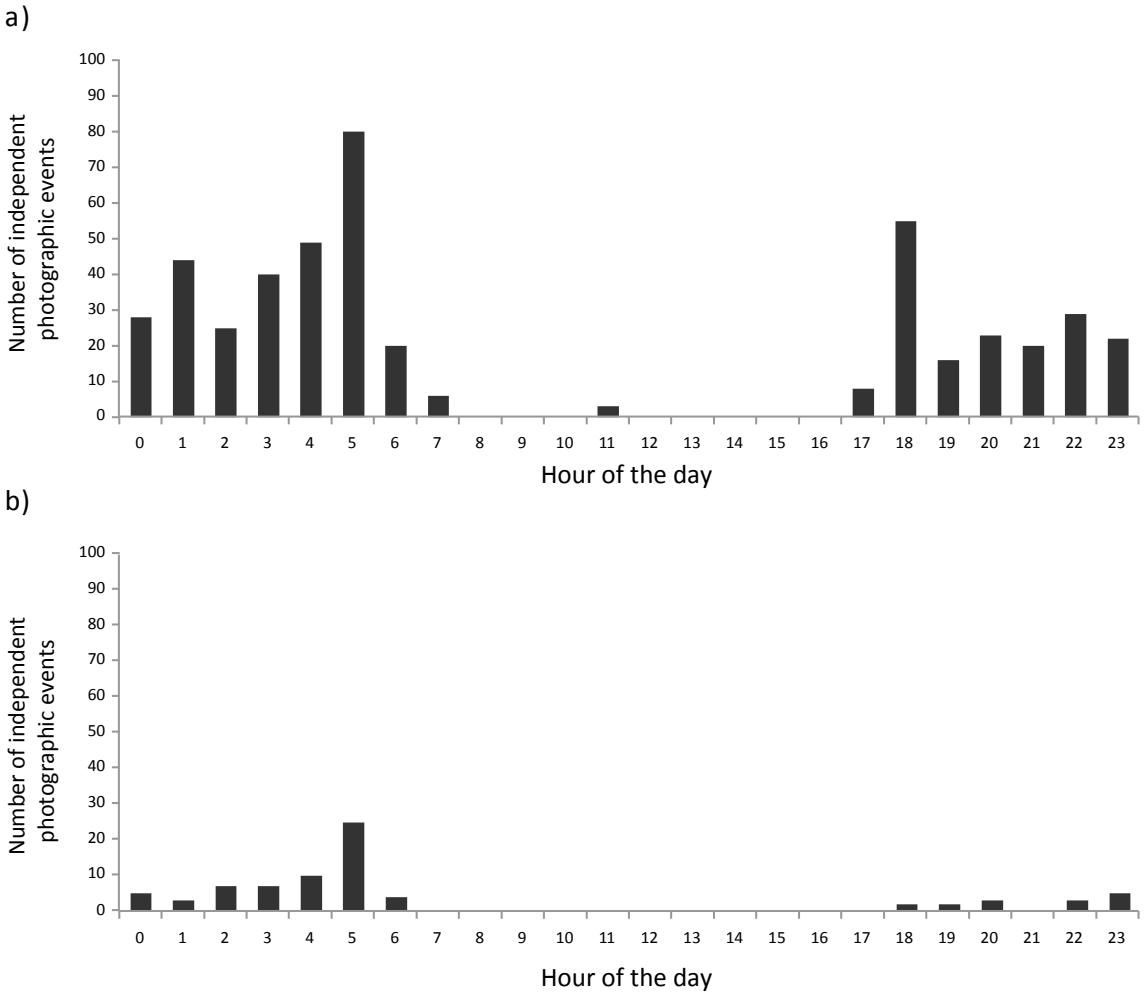
**Occupancy**: Soft-furred sengis were detected in all four camera grids with similar occupancy in the three northern coastal forests and lower occupancy in Arabuko-Sokoke Forest (Table 62).

**Table 62** Naïve and modelled occupancy and detection probability estimates for soft-furred sengi in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.47 | 0.48 (±0.12) | 0.47 (±0.06) |
| Boni forest | 0.46 | 0.46 (±0.14) | 0.68 (±0.07) |
| Dodori NR | 0.50 | 0.51 (±0.11) | 0.57 (±0.07) |
| Arabuko-Sokoke Forest | 0.26 | 0.26 (0.10) | 0.54 (0.07) |

**Behaviour**: Soft-furred sengis are most active in the early morning and late evening. They were almost exclusively detected nocturnally with only a single event occurring between 07:00 and 17:00 (Figure 62).

**Figure 62** Temporal distribution of soft-furred sengi records in (a) the Boni-Dodori forest system and (b) the Arabuko-Sokoke Forest through the 24 hour cycle.



## Summary

Based on earlier Boni-Dodori forest system surveys, the ranges of the rufous sengi and four-toed sengi have been extended to the Kenyan northern coastal forests between the Tana River and the Somali border (Andanje et al. 2010). The camera-trap survey has provided new data on their activity patterns and relative abundance (Figure 63). Like many other species they show generally higher detection rates in the Boni-Dodori system than at Arabuko-Sokoke Forest. Ability to distinguish the two species involved may significantly affect interpretation of these preliminary observations. Camera-trapping may be of limited use in resolving this issue, although future tests of white flash cameras to provide colour images at night might be useful.

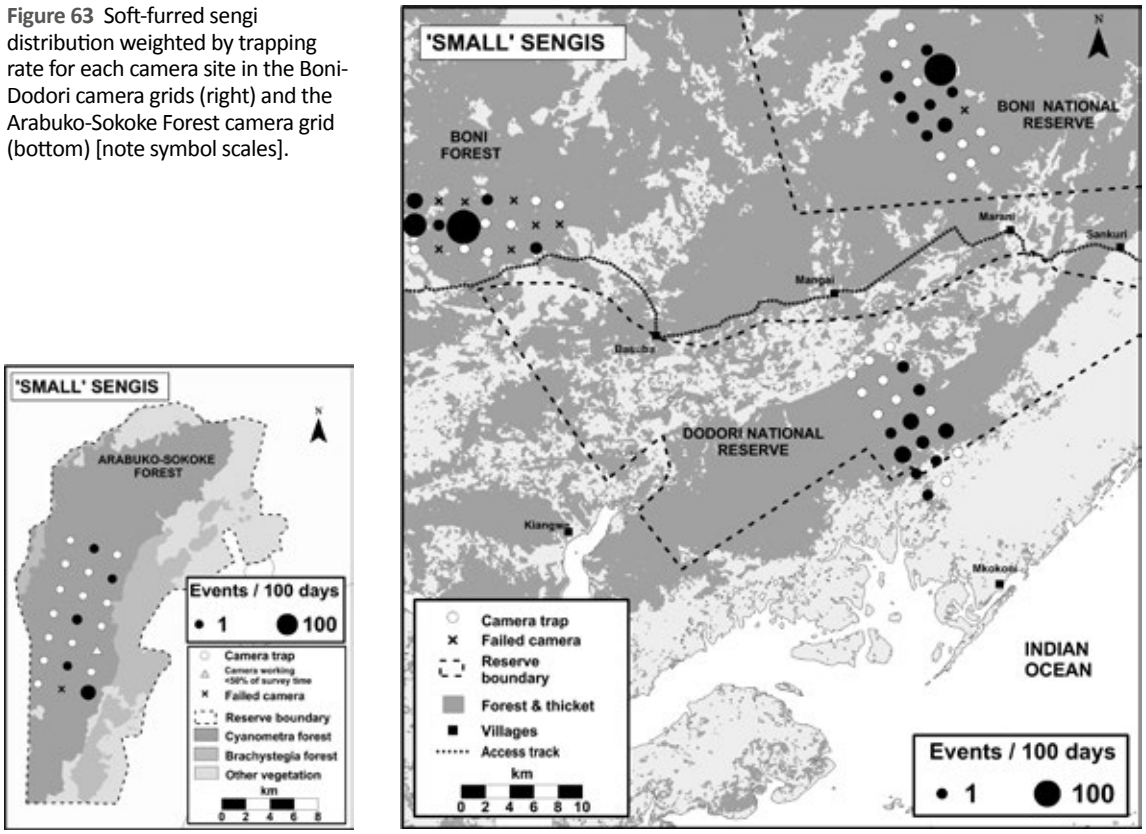



**Figure 63** Soft-furred sengi distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

# 30 *Rhyncocyon sp.*

**Common names**
Giant sengi (English)


a) Golden-rumped sengi recorded in Arabuko-Sokoke Forest

b) The giant sengi recorded in the northern coastal forests

**Species description**
The golden-rumped sengi of Arabuko-Sokoke forest is well-known for its distinctive colour pattern; the pale yellow rump colour shows well in camera trap images. Camera trapping has confirmed that the giant sengis found north of the Tana river in the Boni-Dodori forest system consistently lack golden rump markings. Dark colouring is restricted to the rump and thighs, distinguishing it from the black-and-rufous sengi (*R. petersi*) found in southern coastal Kenya, where black colouration extends over most of the rear half of the body. The facial pelage of *R. petersi* is also bright rufous, rather than the grizzled yellow-brown seen on the Boni giant sengi (Andanje et al.2010). The status of boni giant sengis remains unresolved - see summary.

**Global conservation status**
IUCN Red List Status: Endangered (Rhyncocyon chrysopygus)

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: Not Listed.
African Convention on the Conservation of Nature and Natural Resources: Not Listed.

***Camera-trap survey results***

**Relative abundance:** The Boni giant sengi appears to be considerably more abundant north of the Boni-Dodori corridor (trapping rate = 6.5) than south of the corridor (trapping rate = 1.49). The golden-rumped elephant shrew was found at similar lower frequency in the Arabuko-Sokoke Cynometra forest (Table 63).

**Table 63** Giant sengi trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 92 | 1670 | 5.59 (±0.66) |
| Boni forest | 82 | 1026 | 8.09 (±0.79) |
| Dodori NR | 17 | 1087 | 1.49 (±0.41) |
| Arabuko-Sokoke Forest | 30 | 2049 | 1.49 (±0.27) |

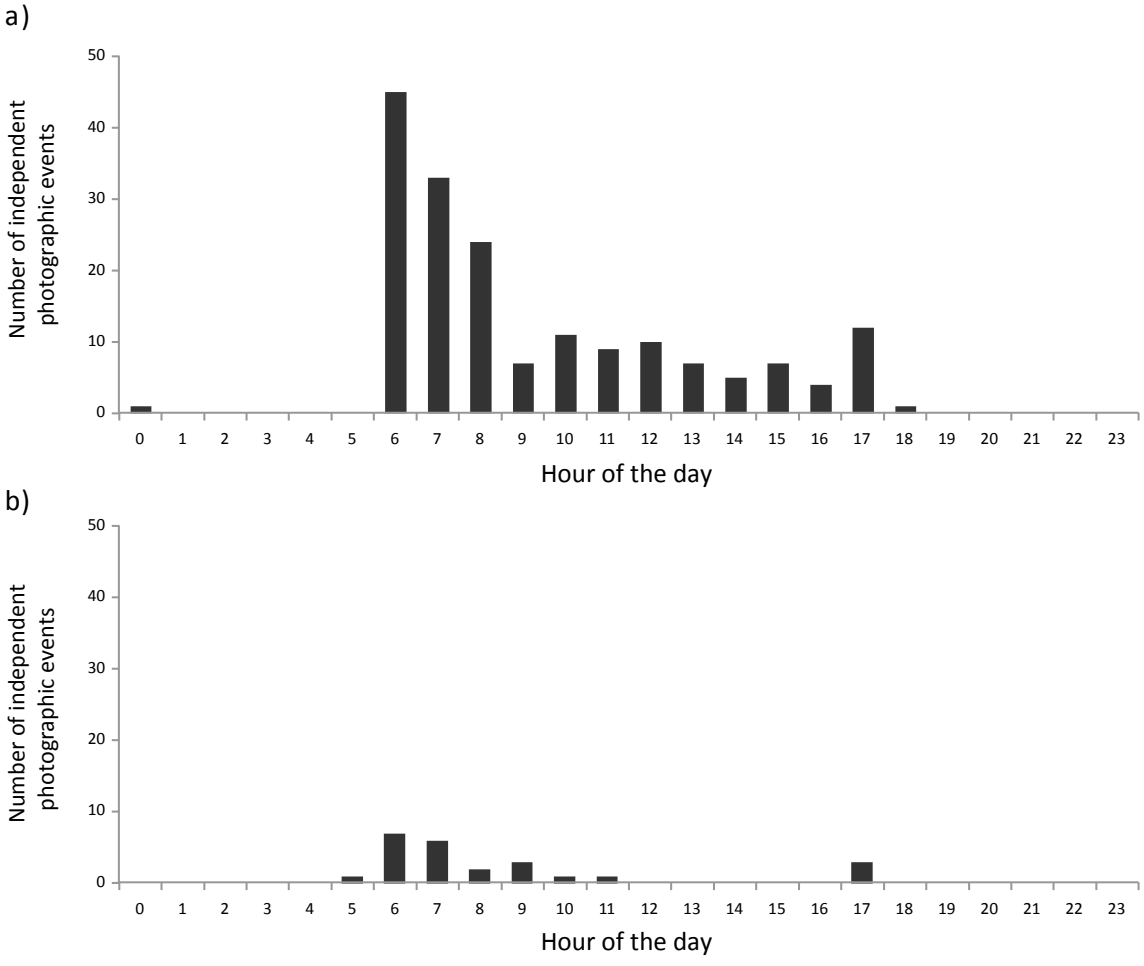
**Occupancy**: Giant sengis were detected in all four camera grids. Modelled occupancy estimates followed a similar pattern to trapping rates with the highest occupancy values in the two more inland northern forests, Boni NR and Boni forest compared to Dodori NR. The golden-rumped elephant shrew was also found to have relatively high occupancy in Arabuko-Sokoke forest (occupancy = 0.58 [0.13]) (Table 64).

**Table 64** Naïve and modelled occupancy and detection probability estimates for the giant sengi in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.79 | 0.80 (±0.10) | 0.43 (±0.05) |
| Boni forest | 0.85 | 0.86 (±0.10) | 0.42 (±0.06) |
| Dodori NR | 0.20 | 0.22 (±0.10) | 0.36 (±0.12) |
| Arabuko-Sokoke Forest | 0.53 | 0.58 (±0.13) | 0.21 (±0.05) |

**Behaviour**: Camera-trapping data confirms that the giant sengis in this study are almost entirely diurnal. All but one event took place between 06:00 and 1900 (Figure 64). Peak activity occurred at dawn with activity declining until dusk when there was a smaller peak. This behaviour is the opposite of the soft-furred sengi species, which are strictly nocturnal (Figure 62).

**Figure 64** Temporal distribution of giant sengi records in (a) the Boni-Dodori forest system and (b) the Arabuko-Sokoke Forest through the 24 hour cycle.



## Summary

It had been assumed for many years that the giant sengi occurring in the Boni-Dodori forest system were golden-rumped elephant shrew (*R. chrysopygus*). However it is now clear that they do not share the same distinctive markings (Andanje et al. 2010). The Boni giant sengi (as illustrated above in the species camera-trap images) lacks the golden rump that is diagnostic of *R. chrysopygus* and there are other subtle differences in pelage colouration. Superficially it bears closer resemblance to the grey-faced sengi (*R. udzungwensis*), a species from hundreds of kilometres to the south in Tanzania. DNA analysis is currently being undertaken to determine whether this is a new species of *Rhynchocyon*. Preliminary results from one sample individual indicate that despite the lack of a golden rump, the closest relative of the Boni giant sengi is golden-rumped elephant shrew, (Rovero pers. comm.). This accords with geographic proximity, but a larger sample base is required to fully resolve this issue.

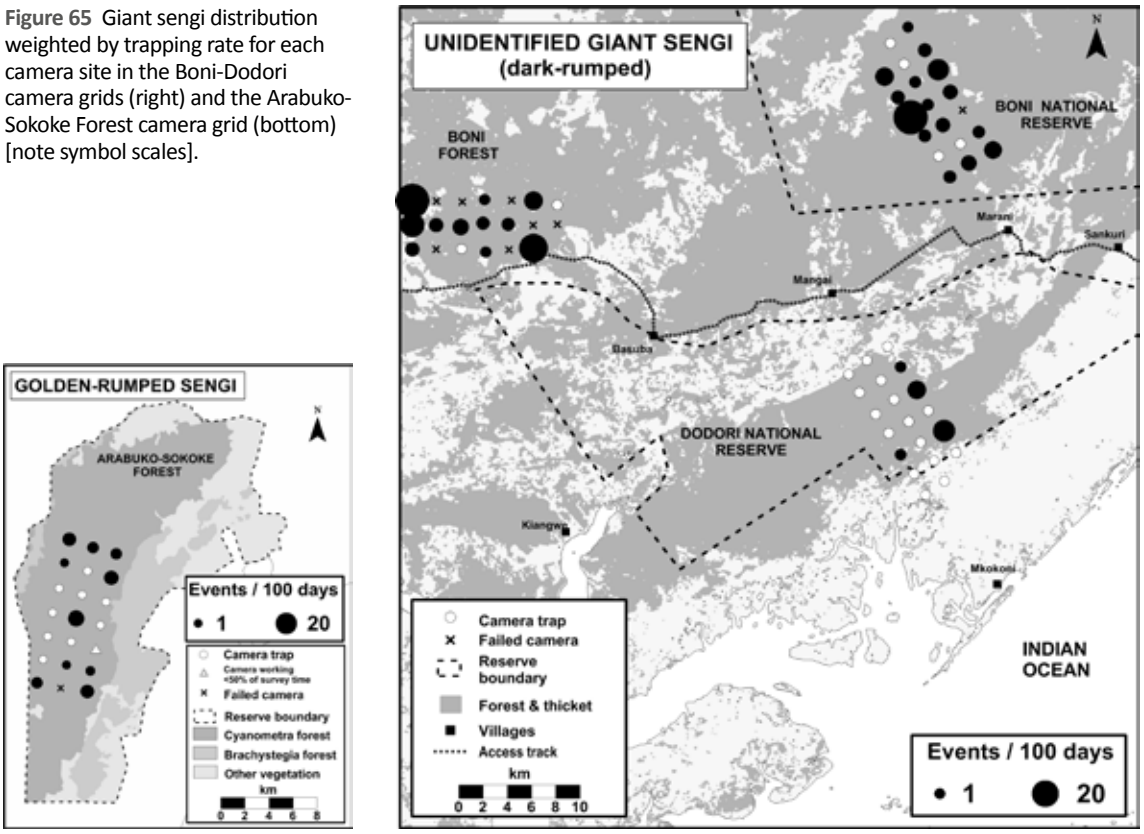



**Figure 65** Giant sengi distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

## Primates

Three species of primates, Sykes's monkey, Yellow baboon and Vervet monkey were detected by the ground based cameras at the four camera grids. Unidentified galagos, possibly representing two different species, were detected once in Boni NR and twice in Arabuko-Sokoke Forest. Sykes's monkeys of the *albogularis* sub-species were detected at Arabuko-Sokoke Forest, while the more brightly marked *albotorquatus* sub-species was present at all three sites in the Boni-Dodori system. Together, they were the most frequently photographed primates (26 events), followed by yellow baboon (12 events) in Boni and Dodori and vervet monkey (nine events) in Dodori only.

A key point to bear in mind is that trapping rate and occupancy values for primate species that include an arboreal element in their behaviour are even less suitable for between species comparisons than is normally the case among strictly terrestrial species. The more arboreal a species is in habit, the more this is true. These parameters are still of value in creating a baseline for future within species comparisons, and are reported here for that purpose.

## 31 *Cercopithecus mitis* (Wolf, 1822) *ssp. albotorquatus* (de Pousargues, 1896) and *albogularis* (Sykes, 1831)

**Common names**
Sykes's monkey, Blue monkey, Zanzibar Sykes's monkey, Pousargues's Sykes's monkey (English); Kima (Swahili).

**Species description**
The Sykes's monkey is 43-52 cm long with a 55-109 cm tail. The coat is short and grizzled, greenish brown on the back and face with black or grey sides, limbs, tail and undersides. A white triangle is present just below the throat; a narrow white collar mark is present on the *albogularis* sub-species (Zanzibar Sykes's monkey) (Arabuko-Sokoke Forest) while the *albotorquatus* sub-species (Pousargues's Sykes's monkey- illustrated) in the Boni-Dodori system shows a much more prominent broad white collar. There are seventeen recognised sub-species of Sykes's monkey.

**Global conservation status**
IUCN Red List Status: Vulnerable (ssp. *albotorguatus*), Least Concern (ssp. *albolgularis*).

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: First Schedule.
African Convention on the Conservation of Nature and Natural Resources: Class B.

***Camera-trap survey results***

**Relative abundance:** Sykes's monkey were recorded at the lowest trapping rates in Arabuko-Sokoke Forest. Overall trapping rate in the Boni-Dodori forest system was still low, averaging 0.61 (Table 65).

**Table 65** Sykes's monkey trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 9 | 1670 | 0.54 (±0.17) |
| Boni forest | 6 | 1026 | 0.50 (±0.22) |
| Dodori NR | 8 | 1087 | 0.70 (±0.23) |
| Arabuko-Sokoke Forest | 3 | 2049 | 0.15 (±0.09) |

**Occupancy**: Zanzibar Sykes's monkeys occurred at lower occupancy values in Arabuko-Sokoke Forest than the Pousargeus's Sykes's monkeys in the Boni-Dodori forest system. Naïve occupancy in the Boni-Dodori camera grids was consistently close to 0.3 (Table 66).

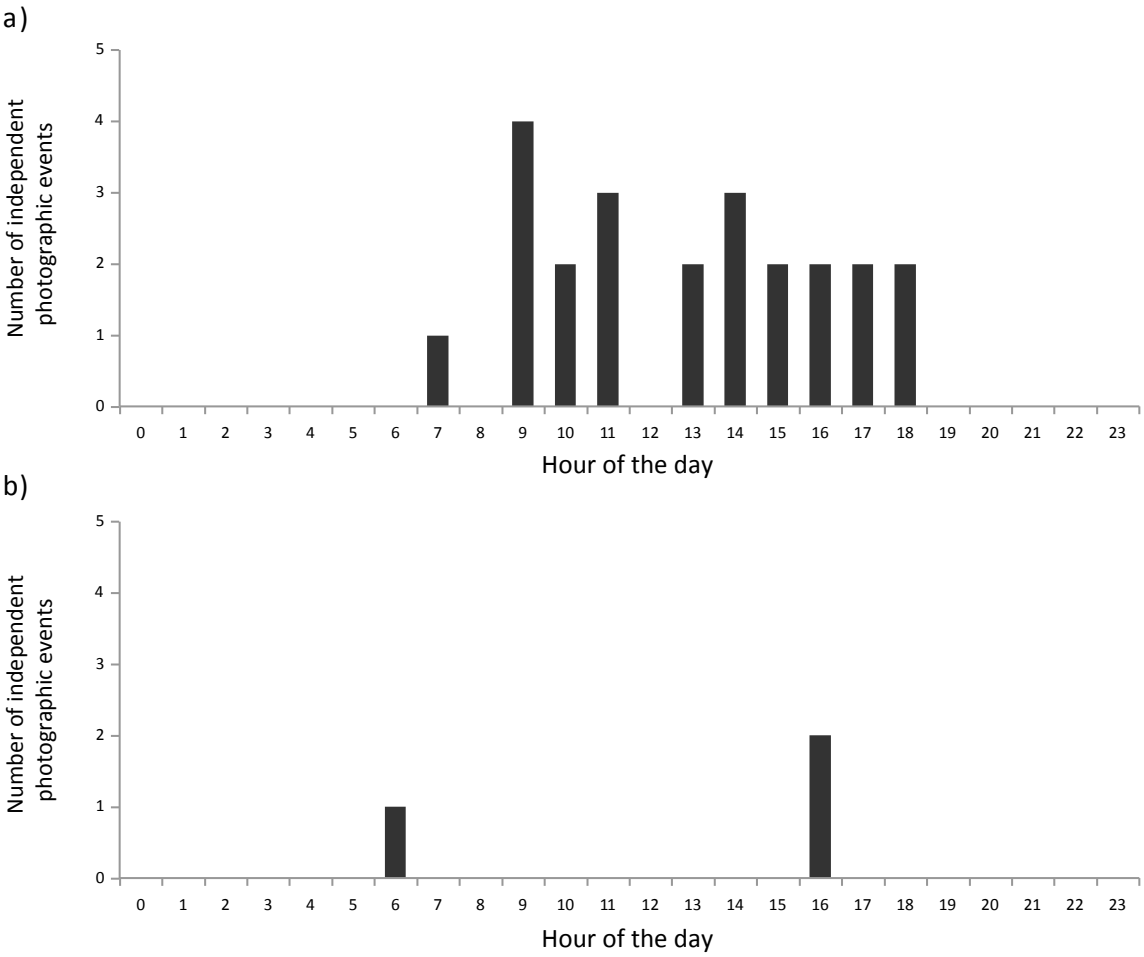
**Table 66** Naïve and modelled occupancy and detection probability estimates for Sykes's monkey in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.32 | 0.65 (±0.38)* | 0.08 (±0.05) |
| Boni forest | 0.31 | 0.77 (±0.66)* | 0.07 (±0.06) |
| Dodori NR | 0.30 | 0.94 (±0.77)* | 0.07 (±0.06) |
| Arabuko-Sokoke Forest | 0.16 | 1.00 (±0.11)* | 0.02 (±0.01) |

* interpret with caution; limited sample data.

**Behaviour**: Sykes's monkey is a diurnal species and all events occurred between 07:00 and 19:00 (Figure 66).

**Figure 66** Temporal distribution of Sykes's monkey records in (a) the Boni-Dodori forest system and (b) the Arabuko-Sokoke Forest through the 24 hour cycle.



## Summary

Social surveys in the Boni Dodori area have suggested that these monkeys are considered a conflict species within the Aweer community. They were detected in all four surveyed coastal forests (Figure 67). Because they are the most arboreal in habit of the larger primates reported here, the trapping rate and occupancy parameters reported should only be used for within species comparisons.

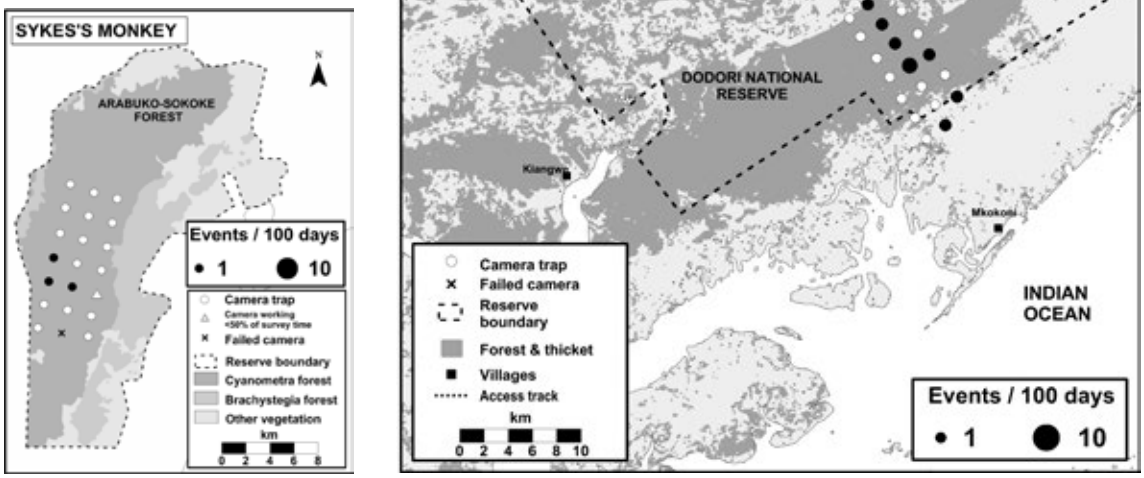



**Figure 67** Distribution weighted by trapping rate for Pousargeus's Sykes's monkey at each camera site in the Boni-Dodori camera grids (right) and Zanzibar Sykes's monkey in the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

## 32 *Chlorocebus pygerythrus*

(F. Cuvier, 1821)

**Common names**

Vervet monkey (English); Tumbili, Ngedere (Swahili).

**Species description**

Easily distinguished from Sykes's monkey by its more uniform and paler pelage contrasting with the dark face, the nomenclature of this coastal representative of the green monkey' group is still subject to debate. Here we follow the treatment in Mammals of Africa (Isbell and Jaffe 2013), which notes that the coastal form is also known as Manda vervet monkey *C. p. excubitor*. The vervet monkey has a 38-62 cm body with a 50-65 m tail. It has a grizzled, grey or olive back, crown and outer limbs. The undersides are whitish, the hands and feet are darker and the face and tip of the tail are black.

**Global conservation status**

IUCN Red List Status: Least Concern.

**Legal status**

CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: First Schedule.
African Convention on the Conservation of Nature and Natural Resources: Class B.

***Camera-trap survey results***

**Relative abundance:** The vervet monkey was recorded only in the Dodori camera grid and only at very low frequency (Table 67). It is known to occur in the Arabuko-Sokoke Forest and in the Boni forests but this study did not detect it in these areas.

**Table 67** Vervet monkey trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 0 | 1670 | - |
| Boni forest | 0 | 1026 | - |
| Dodori NR | 9 | 1087 | 0.79 (±0.27) |
| Arabuko-Sokoke Forest | 0 | 2049 | - |

**Occupancy**: The vervet monkey was only detected in the Dodori camera grid with low occupancy (Table 68).

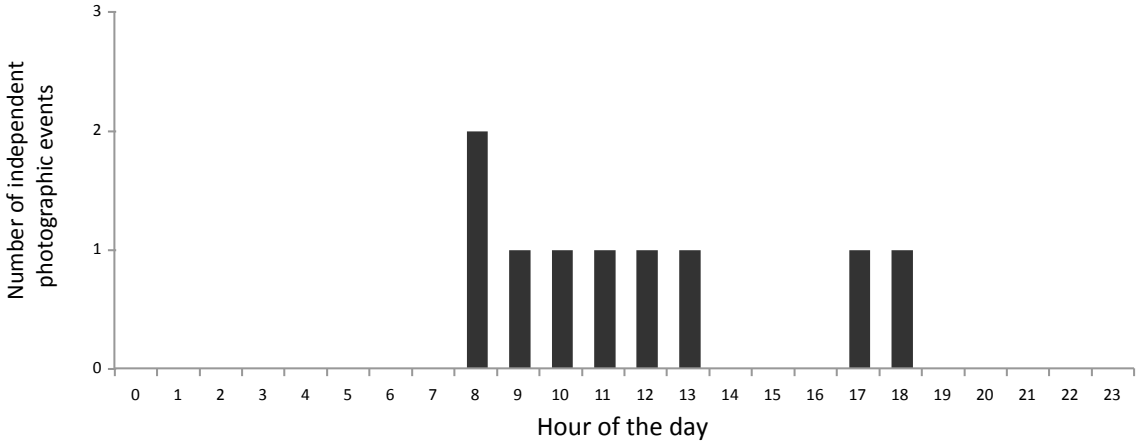
**Table 68** Naïve and modelled occupancy and detection probability estimates for the vervet monkey in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | N/A | N/A | N/A |
| Boni forest | N/A | N/A | N/A |
| Dodori NR | 0.20 | 0.22 (±0.10)* | 0.36 (±0.12) |
| Arabuko-Sokoke Forest | N/A | N/A | N/A |

* interpret with caution; limited sample data.

**Behaviour**: The vervet monkey is a diurnal species and all the detections occurred during the day between 08:00 and 19:00 (Figure 68).

**Figure 68** Temporal distribution of vervet monkey records in the Boni-Dodori forest system through the 24 hour cycle.



## Summary

The vervet monkey is generally considered widespread and common preferring savannah and forest-grassland mosaic habitats, notably Miombo (*Brachystegia*) woodlands. It was only encountered at very low frequency in the Dodori NR. It was detected in the same region that cameras revealed less forest adapted species such as lesser kudu and dik-dik, and this is an indication that like them, it is a more edge adapted species in these habitats than the Sykes's monkeys. Nevertheless, it is considered a conflict species by the Aweer community in this area. It was not encountered in the Arabuko-Sokoke *Cynometra* forest cameras (Figure 69).

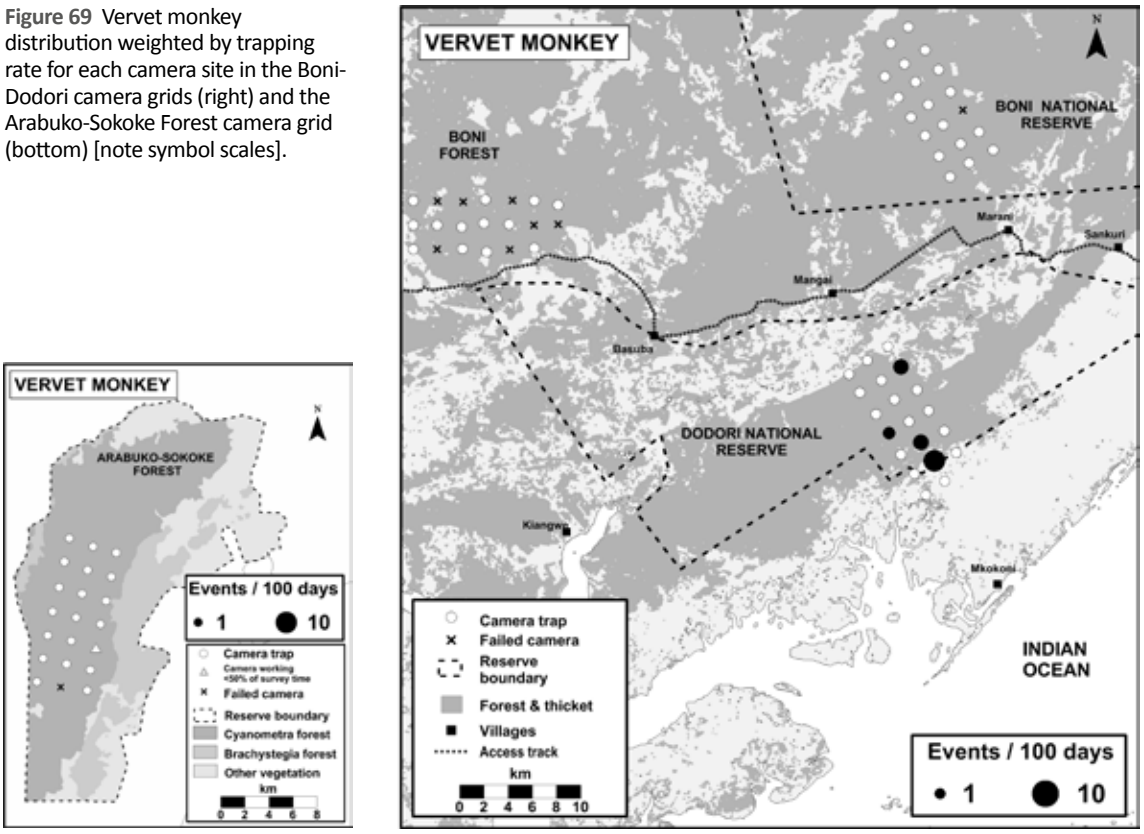



**Figure 69** Vervet monkey distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

## 33 *Papio cynocephalus*
(Linnaeus, 1758)

**Common names**
Yellow baboon (English); Nyani (Swahili).

**Species description**
There are five species in the genus *Papio*, all of which share very similar morphological features and probably intergrade in some parts of the ranges. In yellow baboons, the coat is yellow-brown and grizzled with lighter undersides. It is not usually possible to distinguish yellow and olive baboons in black and white camera-trap images but it is generally accepted that only yellow baboons are found along the East African coastline.

**Global conservation status**
IUCN Red List Status: Least Concern.

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: Not Listed.
African Convention on the Conservation of Nature and Natural Resources: Not Listed.

***Camera-trap survey results***

**Relative abundance:** Yellow baboons were recorded only in the Boni and Dodori NR camera grids and only at very low frequency (Table 69). The number of baboons photographed in a single event ranged from 1 to 10 individuals. It is known to occur in the Arabuko-Sokoke Forest but was not detected by this study.

**Table 69** Yellow baboon trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 1 | 1670 | 0.06 (±0.06) |
| Boni forest | 0 | 1026 | - |
| Dodori NR | 11 | 1087 | 0.97 (±0.29) |
| Arabuko-Sokoke Forest | 0 | 2049 | - |

**Occupancy**: The yellow baboon was only detected in the Boni and Dodori NR camera grids with low occupancy rates (Table 70).

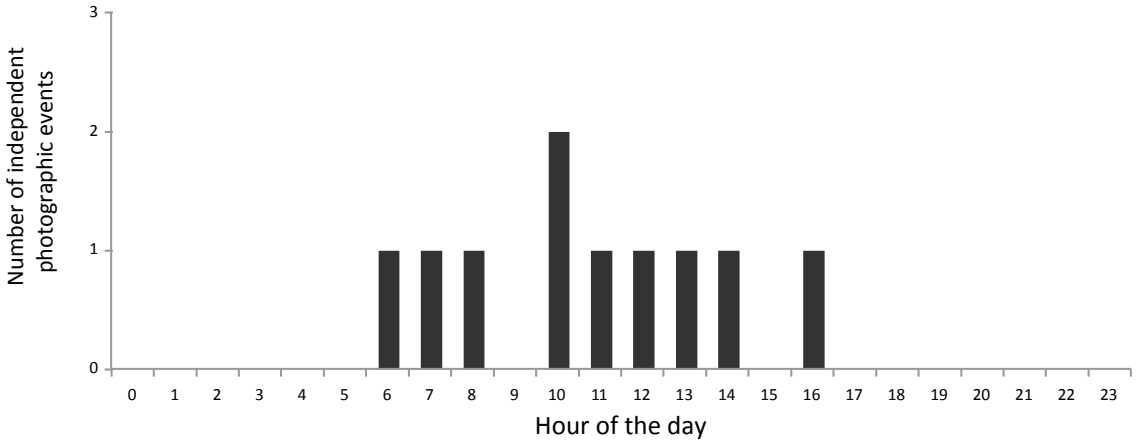
**Table 70** Naïve and modelled occupancy and detection probability estimates for the yellow baboon in the Boni-Dodori and Arabuko-Sokoke Forest camera sampling grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.05 | 0.05 (±0.00)* | 0.01 (±0.01) |
| Boni forest | N/A | N/A | N/A |
| Dodori NR | 0.30 | 0.45 (±0.20) | 0.19 (±0.09) |
| Arabuko-Sokoke Forest | N/A | N/A | N/A |

* interpret with caution; limited sample data.

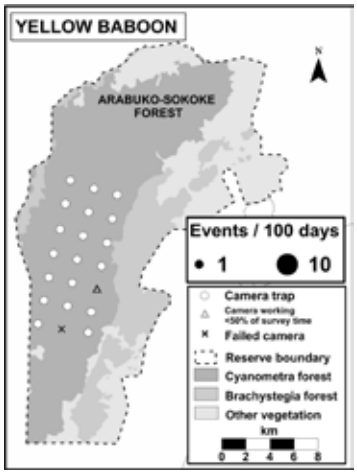
**Behaviour**: Yellow baboons are diurnal with all detections occurring during the day between 06:00 and 17:00 (Figure 70).

**Figure 70** Temporal distribution of yellow baboon records in the Boni-Dodori forest system through the 24 hour cycle.



## Summary

The yellow baboon is widespread and common across Miombo (*Brachystegia*) woodland as well as dry bushland, thickets, steppes and the coastal littoral. It was encountered at low frequency in the two northern NR forests, but not encountered in the Arabuko-Sokoke *Cynometra* forest (Figure 71). Further surveys in the *Brachystegia* and mixed forests are required to confirm the status of the species in the area. It is considered a conflict species within the Aweer community.



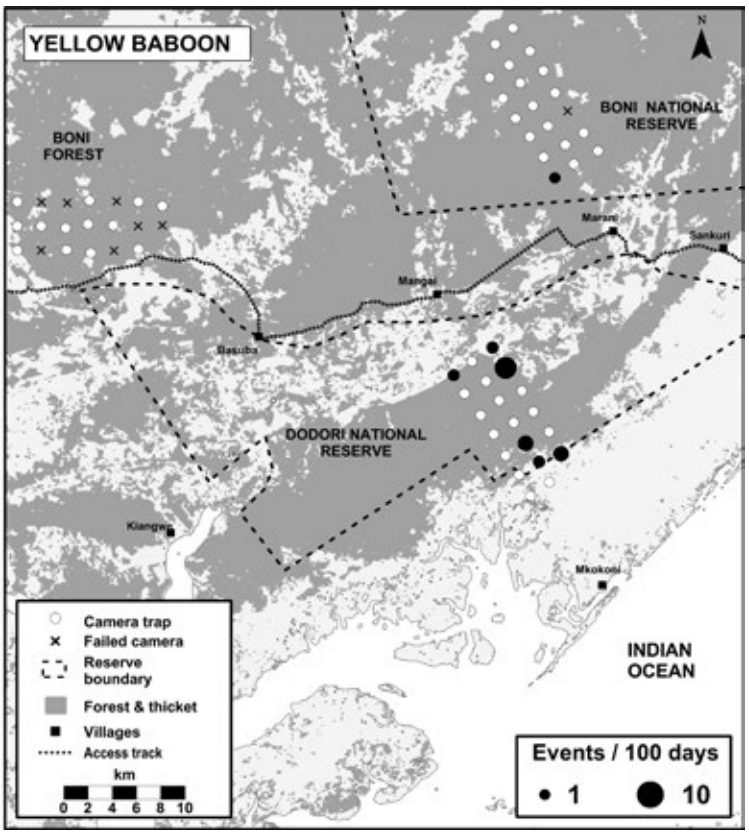




**Figure 71** Yellow baboon distribution weighted by trapping rate for each camera site in the Boni-Dodori camera sampling grids (right) and the Arabuko-Sokoke camera sampling grid (bottom) [note symbol scales].

# 34 *Unidentified galagos (Galagidae sp.)*

**Species description**
There are at least four galago species potentially present in the study areas. These are listed in Table 71 below for reference. It is noted that camera-trapping is not a first choice tool to monitor these small, nocturnal, highly arboreal and very quick moving species. Other methods, notably comparison of calls to voice recordings, are more appropriate.

**Table 71** Summary of Galago species known to exist in the survey areas based on published sources from outside this study.

| Species | Name | Arabuko-Sokoke Forest | Boni forest | Dodori NR | Boni NR |
|---|---|---|---|---|---|
| *Otolemur garnetti* | Small-eared greater galago | Y | Y | Y | Y |
| *Galago senegalensis* | Northern lesser galago | Y | | | |
| *Galago gallarum* | Somali lesser galago | | Y | Y | Y |
| *Galagoides cocos* | Kenya coast dwarf galago | Y | | | |

***Camera-trap survey results***

**Relative abundance:** Unidentified galagos were recorded once only at Boni NR camera grid in the northern forests and on three occasions at two locations in Arabuko-Sokoke Forest, (Table 72).

**Table 72** Galago trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 1 | 1670 | 0.06 (±0.06) |
| Boni forest | 0 | 1026 | - |
| Dodori NR | 0 | 1087 | - |
| Arabuko-Sokoke Forest | 3 | 2049 | 0.15 (±0.09) |

**Occupancy**: Galagos were detected at only one camera site in Boni NR and at two sites in Arabuko-Sokoke Forest (Table 73).

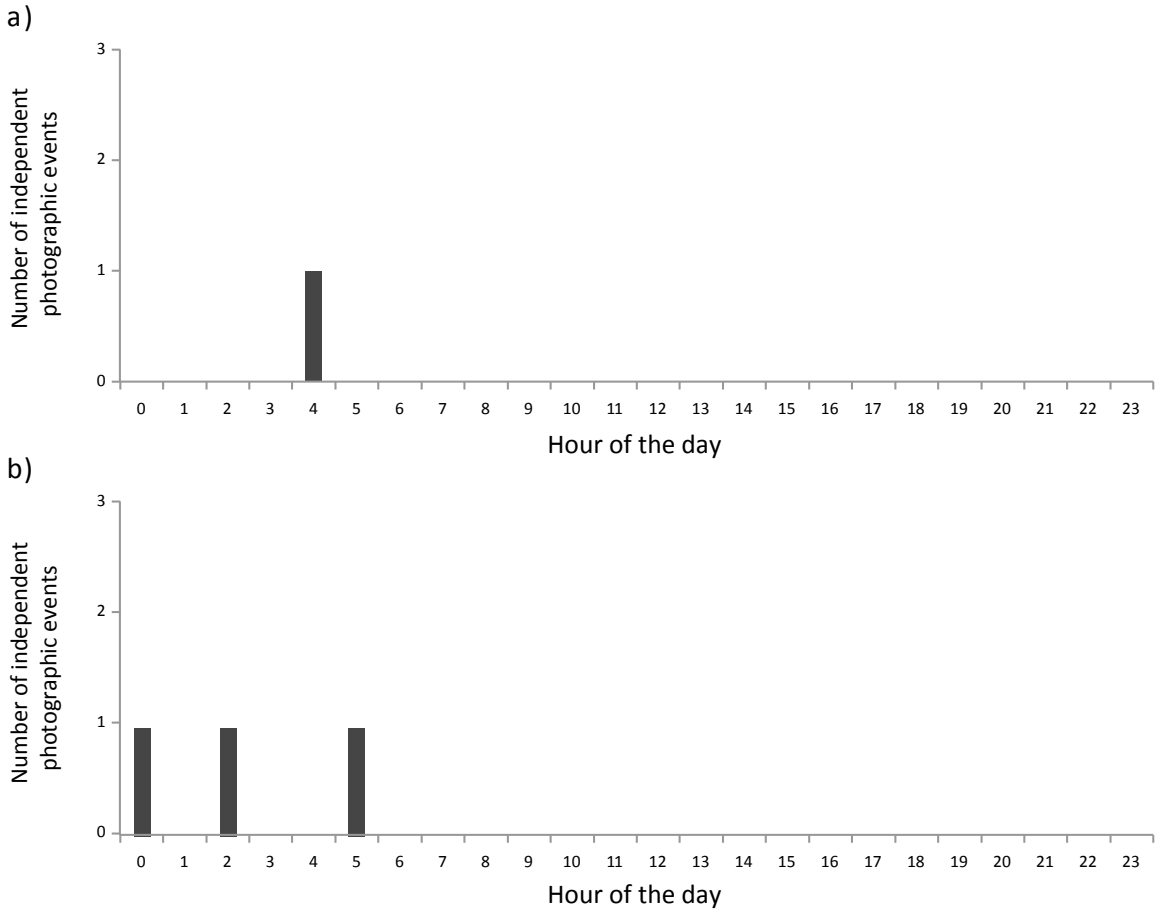
**Table 73** Naïve and modelled occupancy and detection probability estimates for unidentified galagos in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.05 | 0.05 (0.0)* | 0.01 (0.01) |
| Boni forest | N/A | N/A | N/A |
| Dodori NR | N/A | N/A | N/A |
| Arabuko-Sokoke Forest | 0.11 | 0.17 (±0.14)* | 0.10 (±0.08) |

* interpret with caution; limited sample data.

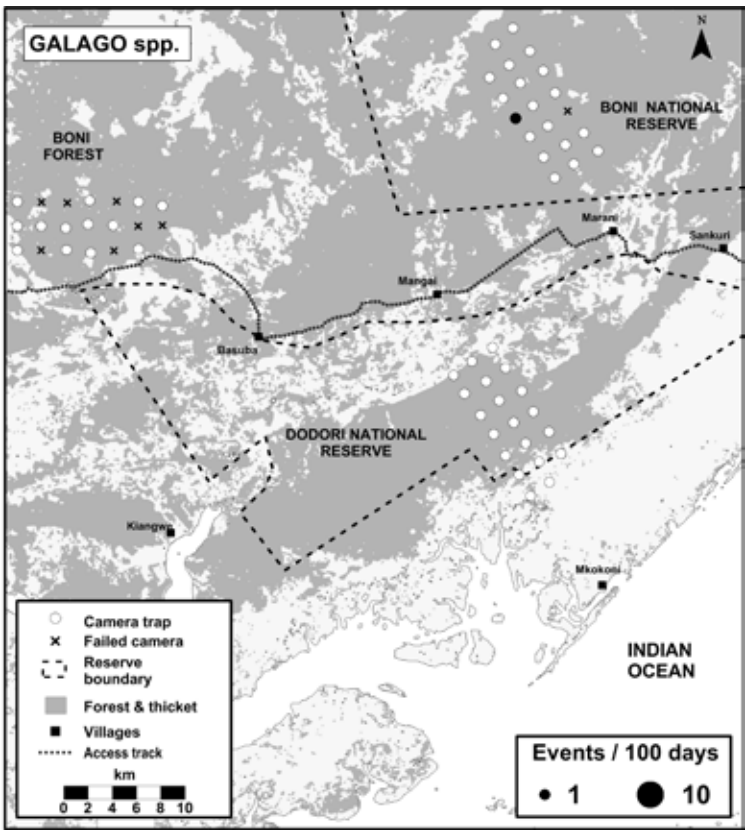
**Behaviour**: Galagos are nocturnal and the four events all occurred at night in this study (Figure 72).

**Figure 72** Temporal distribution of galago records in (a) the Boni-Dodori forest system and (b) the Arabuko-Sokoke Forest through the 24 hour cycle.



## Summary

Galagos were recorded in Boni NR and Arabuko-Sokoke Forest (Figure 73). Camera-trap images suggest at least two different species were recorded, one larger and more robust, the other smaller, but their exact identity remains unknown. Further studies of galagos in this habitat are better conducted by the more specifically adapted techniques mentioned above.



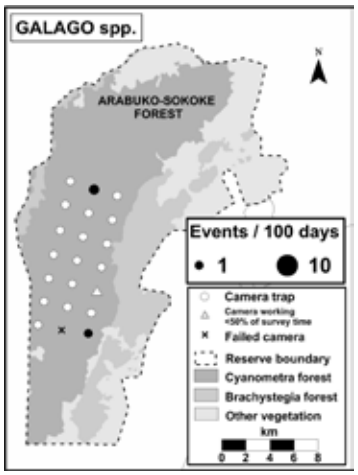




**Figure 73** Galago spp. distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

## Rodents

The camera-traps recorded at least three species of rodent, with the Gambian giant rat the most frequently recorded of this group. With the exception of the largest species, such as porcupines, and the giant rat, most species in this group are too small to be reliably detectable in cameras primarily set up to detect larger mammals. The small rodent species recorded by the cameras in this survey are included only for completeness.

## 35 *Cricetomys gambianus*
(Waterhouse, 1840)

**Common names**
Gambian giant rat, Northern giant pouched rat (English).

**Species description**
The Gambian giant rat can grow up to 90 cm from nose to tail. It gets its name from the large cheek pouches in which it carries food. Its large size, plain pale-toned pelage frequently showing pale colouring to the last third of the tail, give a characteristic appearance.

**Global conservation status**
IUCN Red List Status: Least Concern.

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: Not Listed.
African Convention on the Conservation of Nature and Natural Resources: Not Listed.

***Camera-trap survey results***

**Relative abundance:** The Gambian giant rat was recorded on 72 occasions with over 90% of the events occurring in the Boni-Dodori camera grids (Table 74).

**Table 74** Gambian giant rat trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 38 | 1670 | 2.22 (±0.40) |
| Boni forest | 22 | 1026 | 2.20 (±0.45) |
| Dodori NR | 6 | 1087 | 0.53 (±0.21) |
| Arabuko-Sokoke Forest | 6 | 2049 | 0.29 (±0.12) |

**Occupancy**: The Gambian giant rat was found to be distributed across all four camera grids (Table 75).

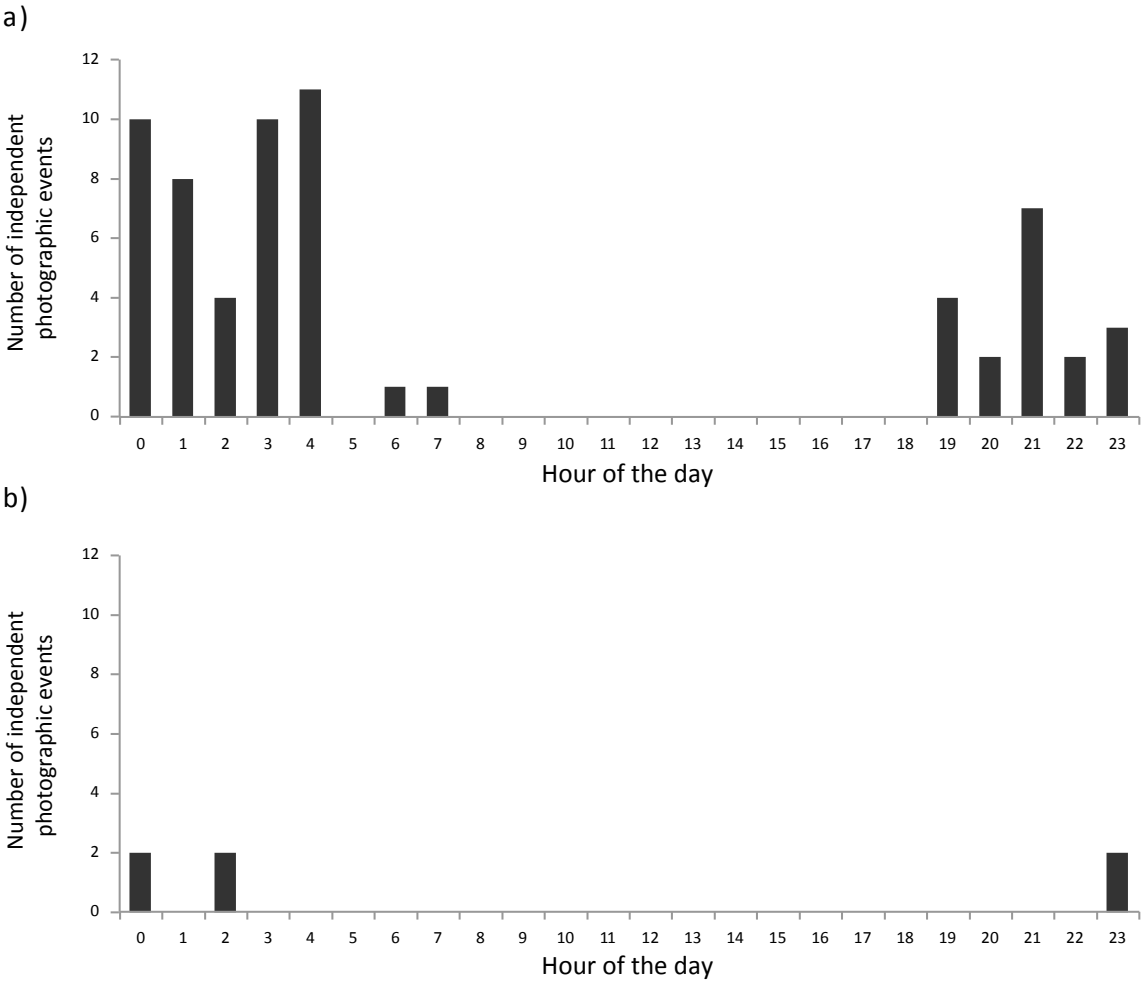
**Table 75** Naïve and modelled occupancy estimates and detection probability estimates for the Gambian giant rat in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.53 | 0.56 (±0.13) | 0.29 (±0.05) |
| Boni forest | 0.39 | 0.40 (±0.14) | 0.38 (±0.09) |
| Dodori NR | 0.25 | 1.00 (±0.04)* | 0.05 (±0.02) |
| Arabuko-Sokoke Forest | 0.21 | 0.32 (±0.18)* | 0.10 (±0.06) |

* interpret with caution; limited sample data.

**Behaviour**: The Gambian giant rat records in this data set showed a nocturnal pattern (Figure 74).

**Figure 74** Temporal distribution of Gambian giant rat records in (a) the Boni-Dodori forest system and (b) the Arabuko-Sokoke Forest through the 24 hour cycle.



## Summary

The Gambian giant rat is well represented in the coastal forests but like many other mammal species, appears to be more readily encountered in the three northern forests than in Arabuko-Sokoke Forest (Figure 75).

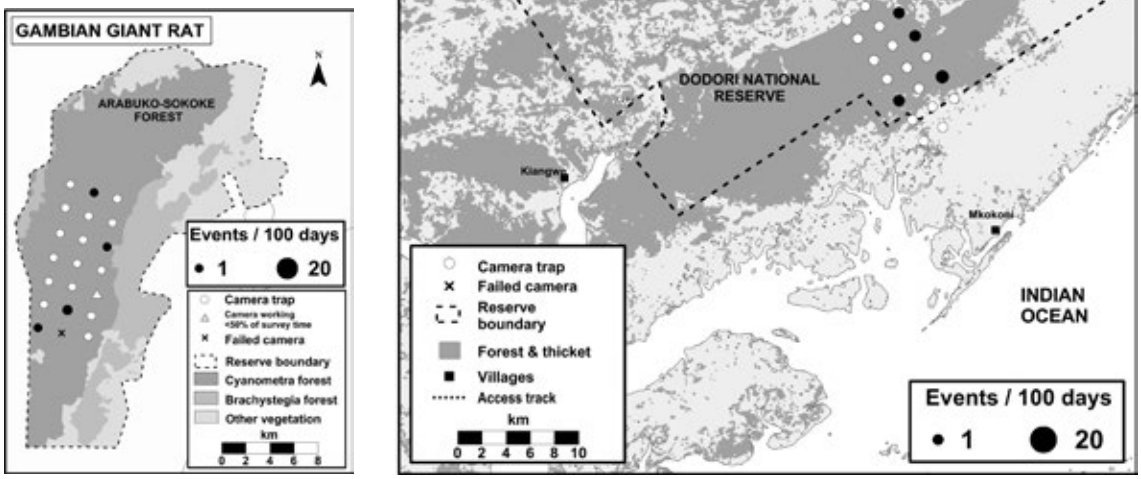



**Figure 75** Gambian giant rat distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

# 36 *Hystrix sp.*

**Common names**
Cape and North African crested porcupine (English); Nnungu (Swahili).

**Species description**
The porcupines are the largest rodents in Africa. Whilst unmistakeable in general appearance, the two species are not easily identified in camera-trap images; Cape crested porcupine (H. *africaeaustralis*) has a white midline to the rump; the north African crested porcupine (H. *cristata*) shows a mottled black and white rump area. These features are not visible in the camera-trap images. Available distribution maps (IUCN Red list and Mammals of Africa) show both species living sympatrically along the Tanzanian border area of southern Kenya but no porcupines at all along the Kenya coast. Hence these records represent a range extension, but the exact species remains to be resolved.

**Global conservation status**
IUCN Red List Status: Least Concern.

**Legal status**
CITES: Not Listed.
Kenya Wildlife (Conservation and Management) Act: Not Listed.
African Convention on the Conservation of Nature and Natural Resources: Not Listed.

***Camera-trap survey results***

**Relative abundance:** Crested porcupine were recorded on 26 occasions (Table 76).

**Table 76** Crested porcupine trapping rates in the Boni-Dodori and Arabuko-Sokoke Forest camera grids. Trapping rate was calculated as the mean of the number of independent photographic events per trap day times 100.

| Camera grid | Number of events | Number of camera-trap days | Trapping rate (±SE) |
|---|---|---|---|
| Boni NR | 7 | 1670 | 0.42 (±0.15) |
| Boni forest | 6 | 1026 | 0.60 (±0.28) |
| Dodori NR | 10 | 1087 | 0.90 (±0.26) |
| Arabuko-Sokoke Forest | 3 | 2049 | 0.15 (±0.08) |

**Occupancy**: Crested porcupine were patchily distributed, detected at 11 sites across the Boni, Dodori and Boni forest camera grids and 2 camera locations in the Arabuko-Sokoke Forest camera grid (Table 77).

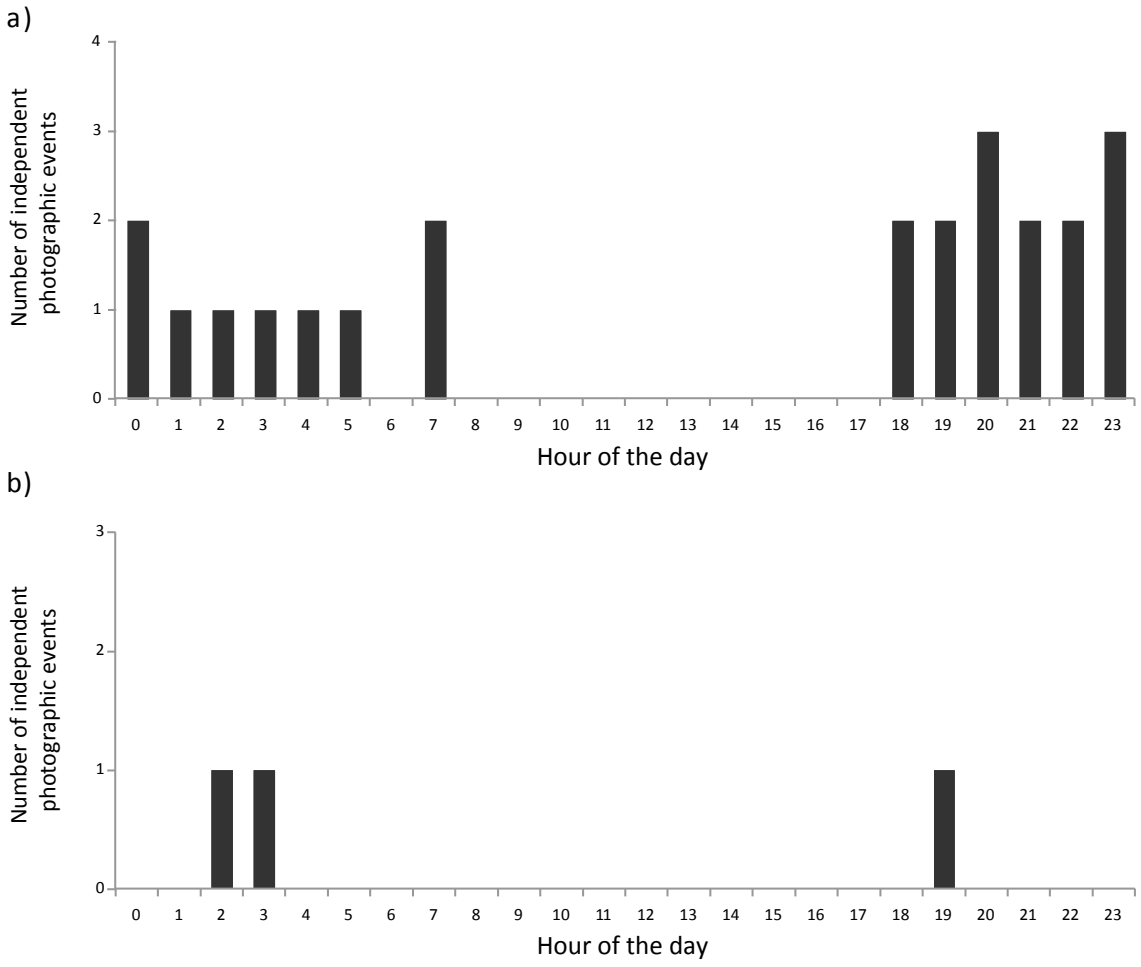
**Table 77** Naïve and modelled occupancy and detection probability estimates for the crested porcupine in the Boni-Dodori and Arabuko-Sokoke Forest camera grids.

| Camera grid | Naïve occupancy | Occupancy estimate Ψ (±SE) | Probability of detection P (±SE) |
|---|---|---|---|
| Boni NR | 0.11 | 0.11 (±0.07)* | 0.38 (±0.12) |
| Boni forest | 0.23 | 0.30 (±0.17)* | 0.18 (±0.10) |
| Dodori NR | 0.25 | 0.34 (±0.15) | 0.23 (±0.10) |
| Arabuko-Sokoke Forest | 0.11 | 0.19 (±0.17)* | 0.08 (±0.07) |

* interpret with caution; limited sample data.

**Behaviour**: The crested porcupine records were primarily nocturnal with no events occurring between 08:00 and 17:00 (Figure 76).

**Figure 76** Temporal distribution of crested porcupine records in (a) the Boni-Dodori forest system and (b) the Arabuko-Sokoke Forest through the 24 hour cycle.



## Summary

Porcupines were present in all four camera grids, confirming their general distribution along the Kenya coast, a significant range extension relative to published maps in key sources for African mammals (see above). Like many larger mammal species, porcupines were recorded at higher rates in the three northern coastal forests than at Arabuko-Sokoke Forest (Figure 77). The question of exact species identity remains to be resolved.

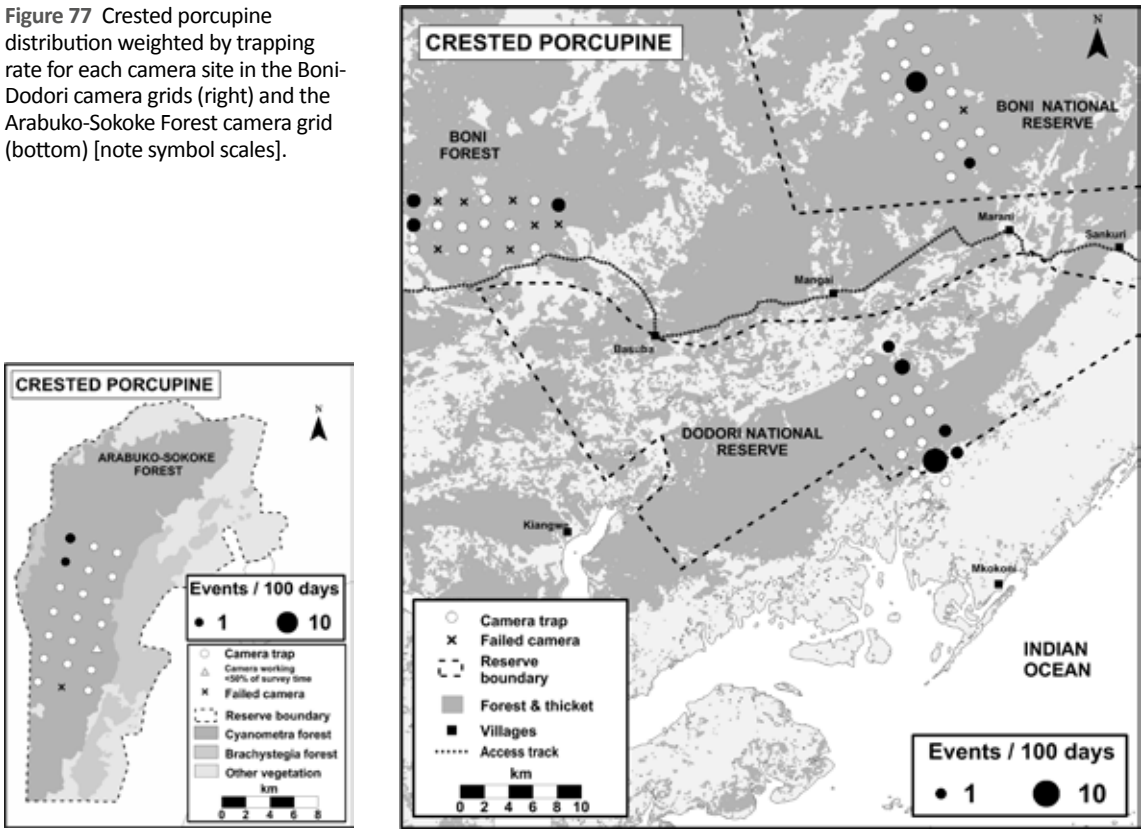



**Figure 77** Crested porcupine distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) [note symbol scales].

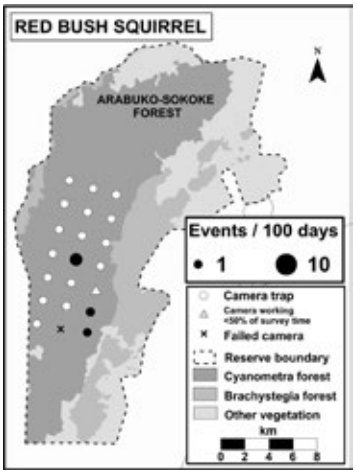
# 37 *Squirrels (Sciuridae sp.)*

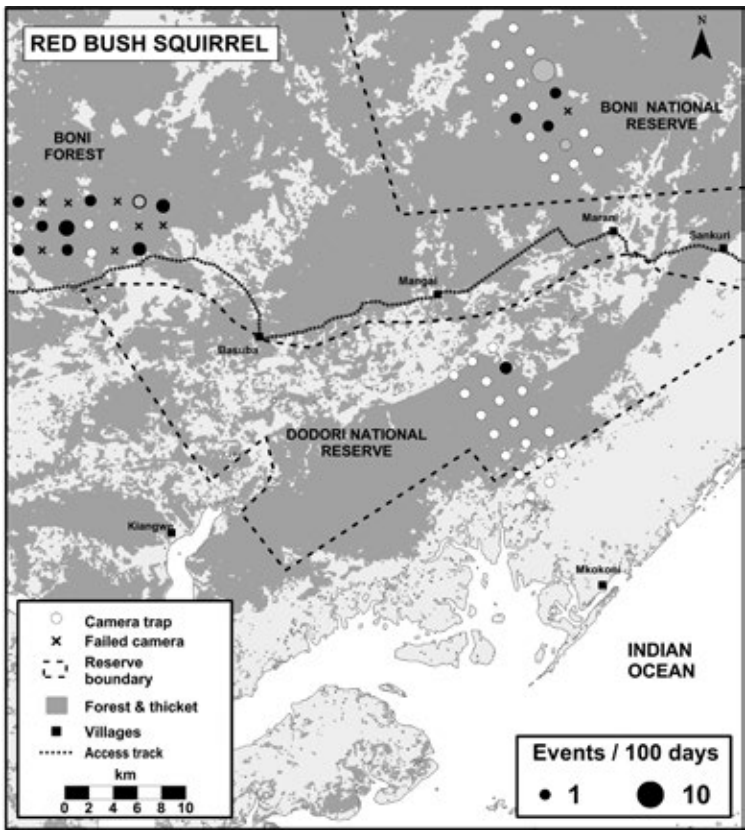
## Summary

Due to the quality of the black and white images taken in this study, and the small size of the animals, it was not possible to reliably identify the species of *Sciuridae* photographed. However, the Red bush squirrel (*Paraxerus palliatus*) was detected in colour images from a preliminary survey prior to this systematic study. Inspection of the photographs suggests that this was probably the dominant species recorded in camera-trap images, but at least one other smaller species, probably *Heliosciurus* sp., was detected (Figure 78).

Camera-trapping is not a method of choice for studying these small, quick moving and arboreal species, but use of colour recording cameras could improve the quality of information available.

**Figure 78** Red bush squirrel distribution weighted by trapping rate for each camera site in the Boni-Dodori camera grids (right) and the Arabuko-Sokoke Forest camera grid (bottom) (Grey circles show distribution of unidentified squirrel species) [note symbol scales].



# CONCLUSIONS AND RECOMMENDATIONS

The camera-trap study has been efficient and successful in providing a quantitative methodology to assess the richness and relative abundance of the medium-to-large terrestrial mammal component at four of Kenya's coastal forests.

**The study has revealed the Boni-Dodori forest system is of major importance to mammal conservation within the eastern African coastal biodiversity hotspot, with indications that it remains relatively undisturbed, holding complete and fully functioning communities of predators and herbivores.**

**The study recommends that this status is recognised and incorporated into future land use planning for the area, with a focus on findings ways for the local communities to integrate development of the region while sustaining and gaining benefit from this unique heritage.**

Thirty eight mammal species were found in the Boni-Dodori forest system. In order to compare species richness between sites species composition is standardised with respect to habitat preference and body size. Twenty three forest and mixed habitat terrestrial medium-to-large mammal species (>0.5 kg adult body weight) have been confirmed in the northern coastal forest system out of the 38 mammal species recorded. In comparison, in Arabuko-Sokoke Forest, the only other large coastal forest reserve south of the Tana River, 20 mammal species were recorded of which 14 were forest and mixed habitat terrestrial medium-to-large mammal species.

An outstanding result of our study has been that the Critically Endangered Aders' duiker's status, as measured by two metrics (camera-trapping rate and occupancy), were both one to two orders of magnitude greater at all three northern forest sites, compared to the Arabuko-Sokoke Forest. The very high levels of occupancy in the Boni-Dodori camera-trap grids, very close to or at 100%, suggest that this species is consistently distributed through this habitat. The replicate count N-mixture model gave an estimate of 27 Aders' duikers (SE = 5.2, 95% CI = 16.74 – 37.13) across 19 camera sampling units in Boni NR. This was based on an average home range of 19.2 ha for Aders' duiker. This estimate was derived indirectly from regression analysis of home range against body weight using the most complete home range estimates available from radio telemetry studies of four other forest duiker species. Using the information that occupancy was effectively 1 and an assumption that each camera sampling unit was located within a separate home range, a density estimate of 7.3 duikers / $km^2$ (95% CI = 4.5 – 10.1 duikers / $km^2$) was obtained. Applying this density estimate to the 84 $km^2$ Boni NR survey grid, we conclude an estimate of approximately 600 Aders' duikers in this sample area.

The potential forest and thicket area measured from the classified map (Figure 6 shows a large part of the area) is at least 3,000 $km^2$. This more than triples the combined previously known range of Aders' duiker; 420 $km^2$ Arabuko-Sokoke Forest and less than 500 $km^2$ of scattered duiker habitat across five isolated forests on Unguja Island in Zanzibar (Finnie 2002). These new data strongly indicate that the Boni–Dodori forest system is the most important known population centre for this critically endangered species.

Other notable findings in the northern coastal forests include:

1. A significant population of a very distinctive form of the giant sengi in the northern coastal forests, with the corollary that the range of the better known golden-rumped elephant shrew in Arabuko-Sokoke Forest could now be even smaller than previously understood.

2. Range extensions for rufous sengi and four-toed sengi (confirming observations from the pilot study; Andanje et al. 2010).

3. Confirmation of range extension for the Sokoke bushy-tailed mongoose in the northern coastal forest system. The species was first reported from Milimani in Boni in 1995 (Engel and van Rompaey 1995 quoted in Mammals of Africa, Taylor 2013).

4. Recording of three Suid species living in close proximity in Boni forest: Common warthog; Desert warthog and bushpig.

5. Presence of important population of African wild dog (listed as 'Endangered') confirmed alongside complete suite of large carnivores (lion, leopard and spotted hyaena).

6. The results also indicate higher density of suni and Harvey's duiker in the northern coastal forest relative to Arabuko-Sokoke Forest with range extension for Suni: IUCN Red List indicates northern limit of Suni as 'lower Tana River'.

7. Range extension of the caracal based on the IUCN Red List distribution map.

8. Range extension confirmation of porcupines along the central and north Kenyan coast relative to IUCN Redlist and Mammals of Africa maps.

9. Range extension for the blue duiker (*Philantomba monticola*) relative to published distribution maps (Kingdon 1997; East 1999; IUCN SSC Antelope Specialist Group 2008). The distance from the nearest known population is over 200 km.

10. Comparative lack of human activity in the northern coast forest camera grids during the sampling periods (with no people detected in any camera images).

11. Besides revealing a greater number of species in the Boni-Dodori forest system compared to Arabuko-Sokoke Forest, camera-trap trapping rates were higher (often much higher) at Boni-Dodori for every one of the 18 species shared between the two sites. The two species unique to the Arabuko-Sokoke Forest in this data set had exact equivalents in the Boni-Dodori forest system (the two different giant sengis and the two forms of Sykes's monkey). This further underlines the conservation significance of the Boni-Dodori forest system as a relatively undamaged and well-populated wildlife zone containing unique mammalian diversity and richness, in addition to biodiversity in numerous other organisms.

Logistics and resources prevented simultaneous operation of camera grids in the four forest sites. Consequently results at each site were obtained at different periods of the year. The region typically receives bi-modal annual rainfall (April to June and November to December, ASFMT 2002). Our camera grids were active in both seasons in northern coastal forests and Arabuko-Sokoke Forest. Because of this and the relative stable forest interior of the sites, we consider that the large differences between the camera-trapping rate and occupancy observed for species such as Aders' duiker between Arabuko-Sokoke Forest and the northern coastal forest system are unlikely to be the result of a seasonal effect.

The camera-trap data has also provided new insights on the activity patterns and spatial associations of small forest antelopes in this system. Suni is the only forest antelope species to maintain a consistent level of nocturnal activity ($\chi^2 = 34$, $P < 0.001$). However, levels of nocturnal activity were significantly higher at Arabuko-Sokoke Forest ($\chi^2 = 15$, $P < 0.001$) and it would be useful to test if this trend can be related to higher levels of disturbance and hunting, which might be expected because of the much higher human population density around that forest.

The forest cover map (Figure 6) also helps identify future camera-trap study areas and highlights the potentially isolated status of the forest and thicket habitat of Dodori NR. This sector is separated over much of its length by a wide belt of grassland, through which the major vehicle access route runs, linking the four main villages of the area. Whilst this situation is likely to have been stable as part of the forest grassland mosaic, with the grasslands inhabited by species such as Haggard's oribi (East 1999), this geography emphasises the need for conservation management and planning to retain the current connectivity of the forest system.

The area represents the only remaining sector of the Kenya coastline retaining a significant frontage of undisturbed natural habitat sequences, transitioning from coral reef to lagoons, mangroves, coastal forest and grasslands, through to the interior bush, all supporting endangered biodiversity. This survey also emphasises the undisturbed nature of the mammal community in this zone, underscoring the extremely high biodiversity conservation value of the region. This is all the more urgent given the land-grabs, land conversion, and the felling of indigenous hardwoods associated with and driven by the planned development of a major seaport at Lamu and cross country pipeline development to the same place (Morris and Amin 2012).

In view of these developments and survey results, there is a need to establish long term monitoring in support of a conservation action plan for the forest system.

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# ANNEX

**Regional medium-to-large mammal species list for northern coastal Kenya based on results of camera-trapping across all four grids, supplemented by species expected to be present in the region according to IUCN Red List distribution maps.**

| | Family | Scientific name | IUCN Red list name | Av. Wt. kg | Habit (1) | Habitat (2) | Habit (3) | Photo (4) | IUCN Redlist |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Erinaceidae | *Atelerix albiventris* | African hedgehog | | T | G | I | N | LC |
| 2 | Viverridae | *Civettictis civetta* | African civet | 11.3 | T | G | C | Y | LC |
| 3 | Viverridae | *Genetta maculata* | Central African large-spotted genet | 1.80 | T/AR | F | C | Y | LC |
| 4 | Felidae | *Panthera pardus* | Leopard | 42.2 | T/AR | G | C | Y | NT |
| 5 | Felidae | *Panthera leo* | Lion | 133.3 | T | B-G | C | Y | V |
| 6 | Felidae | *Caracal aurata* | African golden cat | | T | F | C | N | NT |
| 7 | Felidae | *Caracal caracal* | Caracal | 11.5 | T | G | C | Y | LC |
| 8 | Felidae | *Felis silvestris lybica* | Wild cat | | T | B-G | C | N | LC |
| 9 | Felidae | *Leptailurus serval* | Serval | | T | | C | N | LC |
| 10 | Hyaenidae | *Crocuta crocuta* | Spotted Hyena | 52.00 | T | B-G | C | Y | LC |
| 11 | Canidae | *Lycaon pictus* | African wild Dog | 22.70 | T | B-G | C | Y | EN |
| 12 | Herpestidae | *Helogale parvula* | Common dwarf mongoose* | 0.27 | T | B-G | C | Y | LC |
| 13 | Herpestidae | *Atilax paludinosus* | Marsh mongoose | 2.80 | T/AQ | G | C | Y | LC |
| 14 | Herpestidae | *Herpestes sanguineus* | Slender mongoose | 0.55 | T | B-G | C | Y | LC |
| 15 | Herpestidae | *Herpestes ichneumon* | Egyptian mongoose | | T | G | C | N | LC |
| 16 | Herpestidae | *Bdeogale omnivora* | Sokoke bushy-tailed mongoose | 1.2 | T | F | C | Y | V |
| 17 | Herpestidae | *Ichneumia albicauda* | White tailed mongoose | 4.32 | T | G | C | Y | LC |
| 18 | Mustelidae | *Mellivora capensis* | Ratel | 10.60 | T | G | C | Y | LC |
| 19 | Mustelidae | *Aonyx capensis* | African clawless otter | | T/AQ | B-G | C | N | LC |
| 20 | Mustelidae | *Ictonyx striatus* | Zorilla | | T | B-G | C | N | LC |
| 21 | Macroscelididae | *Petrodromus tetradactylus* | Four-toed sengi | 0.20 | T | F | C | Y | LC |
| 22 | Macroscelididae | *Elephantulus rufescens* | Rufous Sengi | 0.06 | T | F | C | Y | LC |
| 23 | Macroscelididae | *Rhynchocyon sp.* | Giant Sengi (Dark rumped) | 0.6 | T | F | C | Y | Unclass. |
| 24 | Macroscelididae | *Rhynchocyon chrysopygus* | Golden-rumped elephant shrew | 0.54 | T | F | C | Y | EN |
| 25 | Cercopithecinae | *Cercopithecus mitis albogularis* | Zanzibar Sykes's Monkey | 4.65 | AR | F | H | Y | LC |
| 26 | Cercopithecinae | *Cercopithecus mitis albotorquatus* | Pousargues's Sykes's monkey | 4.65 | AR | F | H | Y | V |
| 27 | Cercopithecinae | *Chlorocebus pygerthrus* | Vervet monkey | 3.45 | AR/T | G | H | Y | LC |
| 28 | Cercopithecidae | *Papio cynocephalus* | Yellow baboon | 19.25 | T | B-G | O | Y | LC |
| | Galagidae | *Unidentified galago* | Unidentified galago | | AR | | H | Y | |
| 29 | Galagidae | *Otolemur garnetti* | Small-eared greater galago | | AR | | H | N | LC |
| 30 | Galagidae | *Galago senegalensis* | Northern lesser galago | | AR | | H | N | LC |
| 31 | Galagidae | *Galago gallarum* | Somali lesser galago | | AR | B-G | H | N | LC |
| 32 | Galagidae | *Galagoides cocos* | Kenya coast galago | | AR | | H | N | |
| 33 | Leporidae | *Lepus capensis* | Cape hare | | T | G | H | N | LC |
| 34 | Nesomyidae | *Cricetomys gambianus* | Gambian rat | 0.79 | T/AR | G | H | Y | LC |
| | Sciuridae | *Squirrel sp.* | Squirrel sp. | 0.20 | AR | | H | Y | LC |

| | Family | Scientific name | IUCN Red list name | Av. Wt. kg | Habit (1) | Habitat (2) | Habit (3) | Photo (4) | IUCN Redlist |
|---|---|---|---|---|---|---|---|---|---|
| 35 | Sciuridae | *Paraxerus palliatus* | Red bush squirrel | 0.38 | AR | | H | Y | LC |
| 36 | Sciuridae | *Paraxerus ochraceus* | Ochre bush squirrel | | AR | | H | N | LC |
| 37 | Sciuridae | *Heliosciurus undulatus* | Zanj sun squirrel | | AR | | H | N | DD |
| 38 | Hystricidae | *Hystrix cristata* | Crested porcupine | 20.00 | T | G | H | Y | LC |
| 39 | Bovidae | *Sylvicapra grimmia* | Common duiker | | T | B-G | H | N | V |
| 40 | Bovidae | *Philantomba monticola* | Blue duiker | 5.05 | T | F | O | Y | LC |
| 41 | Bovidae | *Cephalophus adersi* | Aders' duiker | 9.10 | T | F | H | Y | CR |
| 42 | Bovidae | *Cephalophus harveyi* | Harvey's duiker | 11.60 | T | F | H | Y | LC |
| 43 | Bovidae | *Nesotragus moschatus* | Suni | 5.20 | T | F | H | Y | LC |
| 44 | Bovidae | *Madoqua kirkii* | Kirk’s dik-dik | 4.88 | T | B-G | H | Y | LC |
| 45 | Bovidae | *Madoqua guentheri* | Guenther’ s dik-dik | | T | B-G | H | N | LC |
| 46 | Bovidae | *Tragelaphus imberbis* | Lesser kudu | 93.75 | T | B-G | H | Y | NT |
| 47 | Bovidae | *Tragelaphus scriptus* | Bushbuck | 35.00 | T | G | H | Y | LC |
| 48 | Bovidae | *Kobus ellipsiprymnus* | Waterbuck | 201.00 | T | B-G | H | Y | LC |
| 49 | Bovidae | *Syncerus caffer* | African buffalo | 598.70 | T | G | H | Y | LC |
| 50 | Suidae | *Potamochoerus larvatus* | Bushpig | 56.50 | T | G | O | Y | LC |
| 51 | Suidae | *Phacochoerus africanus* | Common warthog | 68.05 | T | B-G | O | Y | LC |
| 52 | Suidae | *Phacochoerus aethiopicus* | Desert warthog | | T | B-G | O | Y | |
| 53 | Elephantidae | *Loxodonta africana* | African elephant | 4640.00 | T | G | H | Y | V |
| 54 | Hippopotamidae | *Hippopotamus amphibious* | Hippopotamus | 1461.00 | T/AQ | B-G | O | Y | V |
| 55 | Orycteropidae | *Orycteropus afer* | Aard-vark | 52.35 | T | G | I | Y | LC |

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