

An assessment of mammals in Naimina Enkiyo Forest, Kenya

Femke Broekhuis^{1*}, Robert H. O'Meara², Sarah O'Meara², Michael Barton³, Christopher Harrell³, Guy Western^{1,4} and Nicholas B. Elliot^{1,5}

¹ Wildlife Conservation Research Unit, Department of Zoology, University of Oxford,
Recanati-Kaplan Centre, Tubney, United Kingdom

² Orkinyil, Nairobi, Kenya

³ Africa Exchange, Nairobi, Kenya

⁴ Rebuilding the Pride, South Rift Association of Land Owners (SORALO), Nairobi,
Kenya

⁵ Mara Lion Project, Kenya Wildlife Trust, Nairobi, Kenya

* Corresponding author

E-mail: femke.broekhuis@gmail.com

Introduction

Many biodiversity hotspots are situated within forests, which are rapidly disappearing along with their associated biodiversity (Brooks et al., 2002, Hansen et al., 2010). In Kenya, approximately 2% of the country is covered by closed canopy forests of which 88% is indigenous (Wass, 1995). The Naimina Enkiyio Forest is one of the few remaining indigenous forests in Kenya and is of major spiritual and cultural importance to the Maasai people (Mbuvi et al., 2015, Kariuki et al., 2016). Access to the resources in the forest is governed by the local community and it is largely as a result of this governance system that the forest has been spared from large-scale exploitation and land conversion (Mbuvi et al., 2015). The forest is believed to be an important wildlife refuge and corridor for species including elephant (*Loxodonta africana*) and lion (*Panthera leo*) but, apart from local knowledge, little is known about its biodiversity. Here we conduct the first formal assessment of the medium to large mammal assemblage of Naimina Enkiyio Forest based on data from camera-traps and opportunistic sightings.

Methods

Study area

The Naimina Enkiyio Forest, also known as the '*The Forest of the Lost Child*', is approximately 330km² in size and is situated in the South of Kenya between the Maasai Mara National Reserve to the West, the Nguruman-Magadi escarpment to the East and the Tanzania border in the South (Fig. 1). This closed canopy, afro-montane, dryland forest, which lies at an altitude of 2200-2400m, is interspersed with open areas consisting of bushes, glades and wetlands (Karanja et al., 2002).

Data collection

A camera-trap survey was conducted during a three-month period from the 1st January to the 31st March 2016. In total 20 infrared, motion triggered camera traps (Bushnell Trophy Cam HD) were systematically placed at 20 sites in a 4x5 grid formation with 1500m between each camera-trap. Each camera was placed perpendicular to the nearest game trail, on a tree at a height of

approximately 90-100cm. The camera traps were active 24hrs a day and were set to take three photographs when triggered. The data from this camera-trap survey were used to determine species presence and occupancy, which we interpreted as the probability of site use as it was possible that the detection histories for the different sites were not independent (Mackenzie and Royle, 2005). Additional information on species presence was obtained via *ad hoc* placement of camera-traps and visual sightings between 1st January 2016 – 31st December 2017.

Data processing and analysis

All photographs were classified according to species using a field guide and tagged in Adobe Lightroom 5.7. Smaller species (<0.5kg) were excluded from the analysis due to difficulties associated with identification. Metadata, including species, date and time when the photographs were taken, were extracted and used to determine species presence and calculate species-specific site use. All photographs of the same species at the same camera-trap were grouped into independent 'events'. An 'event' was defined as a sequence of photographs from a given species occurring after an interval of >60 min from the previous images of the same species at the same camera site (following Tobler et al., 2008, Bowkett et al., 2008). Based on these independent events, species presence, total number of events and the probability of site use (taking into account detection probability) were determined for each of the medium and large mammal species using the ZSL Camera trap software (Davey et al., 2014).

Results and discussion

The results revealed the presence of 24 medium and large mammal species in Naimina Enkiyo Forest (Table 1). In total, 20 species of medium- to large-sized vertebrates were recorded during the three-month camera trap survey including seven species of Carnivora, six species of Cetartiodactyla and three species of Primate. In addition, four species; lion, serval (*Leptailurus serval*), hippopotamus (*Hippopotamus amphibious*) and eland (*Tragelaphus oryx*), were sighted and/or captured through the *ad hoc* placement of cameras. In total, four species found in Naimina

Enkiyio Forest are classified as Vulnerable by the IUCN; leopard (*P. pardus*), lion, hippopotamus and elephant.

Bushbuck (*Tragelaphus scriptus*) was the most recorded species with a total of 1180 independent events and a high probability of site use ($\psi = 0.95 \pm 0.05$; Table 1). Of the four species in the forest that are classified as 'Vulnerable' by IUCN, leopards had the most independent events (N = 58) and had the highest probability of site use ($\psi = 0.81 \pm 0.11$; Table 1 and Fig. 2). The likely reason for this high prevalence is the abundance of prey species, such as bushbuck (Bodendorfer et al., 2006, du Preez et al., 2017). This result is very encouraging especially in light of their recent declines and current population status (Jacobson et al., 2016).

Four species (lion, serval, hippopotamus and eland) were not captured during the camera trap survey but were either sighted or captured on camera traps at a later date. This suggests that there might not be any resident populations and that movements within the forest might only be transitional or seasonal. The camera trap survey may have failed to detect these species due to seasonal differences in presence, occurrence of these species at very low densities, and/or camera trap placement, especially for lions (Cusack et al., 2015). However, the fact that lions are present in this area, suggests that there is potential for connectivity between the Maasai Mara and Magadi, which at a distance of ~80kms is well within the dispersal ability of lions (Elliot et al., 2014).

Determining biodiversity in Naimina Enkiyio Forest is important for securing the future of this sacred forest especially as human pressures are on the rise (Kariuki et al., 2016). Our results provide baseline data necessary for monitoring population trends and highlight the rich mammalian biodiversity of this forest. As camera traps are an effective tool for monitoring biodiversity of terrestrial vertebrates in forests (Ahumada et al., 2013), we recommend conducting a multi-season camera trap survey, which covers both the wet and the dry season, with cameras placed on well-defined trails or roads.

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141 collaboration with ODA.

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144 **Tables**

145 TABLE 1 Species presence of medium and large mammals in the Naimina Enkiyo Forest, Kenya, based on a systematic camera-trap survey (white) and other
 146 observations including sightings and other camera traps that were not part of the survey (light grey). The probability of site use was determined using only
 147 the data that were collected during the systematic camera-trap survey and values (ψ) are presented alongside the associated standard errors (SE).

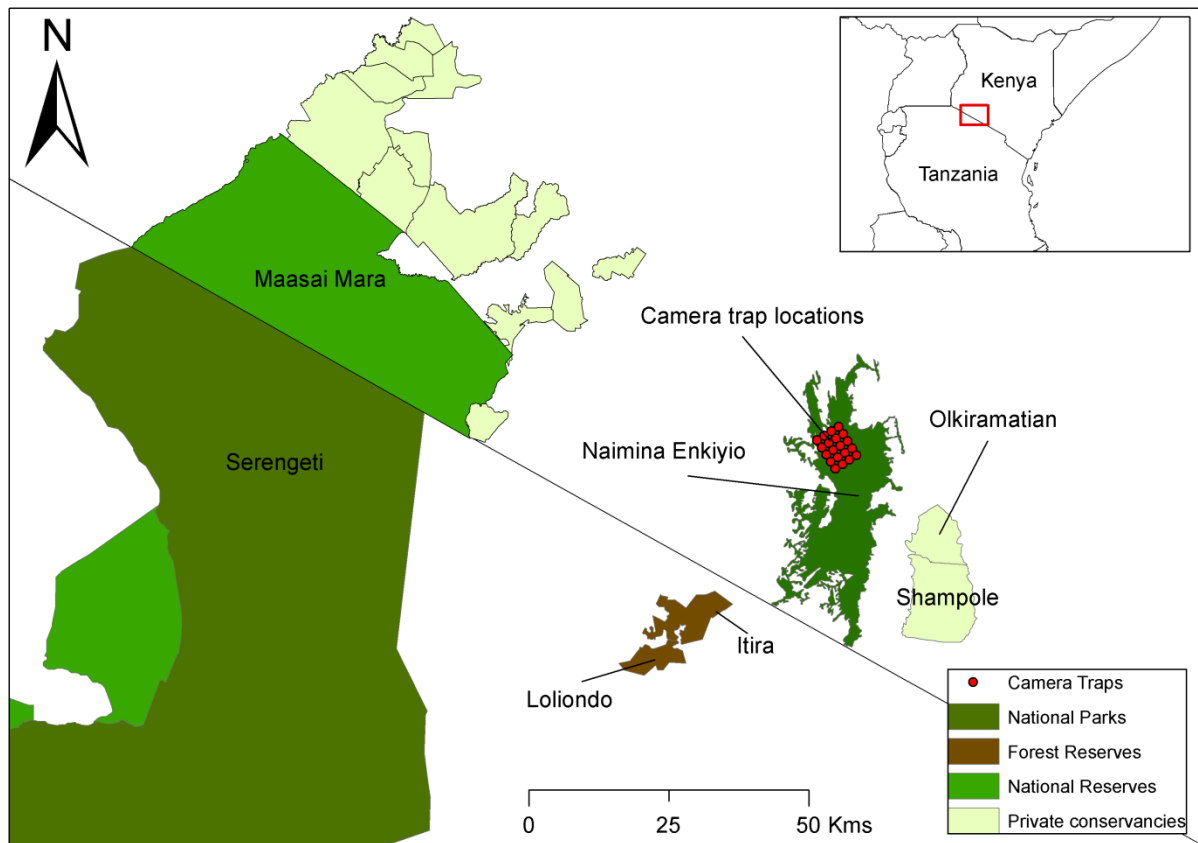
| Order* | Family* | Common name* | Scientific name* | IUCN Red list status* [^] | Number of independent events | $\psi \pm SE$ |
|-----------------|-----------------|---------------------------------|-------------------------------------|------------------------------------|------------------------------|-----------------|
| Carnivore | Felidae | Leopard | <i>Panthera pardus</i> | VU | 58 | 0.81 \pm 0.11 |
| Carnivore | Felidae | Lion | <i>Panthera leo</i> | VU | - | - |
| Carnivore | Felidae | Serval | <i>Leptailurus serval</i> | LC | - | - |
| Carnivore | Hyaenidae | Spotted hyaena | <i>Crocuta crocuta</i> | LC | 131 | 0.65 \pm 0.11 |
| Carnivore | Viverridae | Common genet | <i>Genetta genetta</i> | LC | 227 | 0.80 \pm 0.09 |
| Carnivore | Mustelidae | Striped polecat | <i>Ictonyx striatus</i> | LC | 39 | 0.81 \pm 0.15 |
| Carnivore | Herpestidae | Banded mongoose | <i>Mungos mungo</i> | LC | 14 | 0.23 \pm 0.10 |
| Carnivore | Herpestidae | Marsh mongoose | <i>Atilax paludinosus</i> | LC | 2 | 0.05 \pm 0.00 |
| Carnivore | Herpestidae | Slender mongoose | <i>Herpestes sanguineus</i> | LC | 90 | 0.60 \pm 0.11 |
| Cetartiodactyla | Bovidae | African buffalo | <i>Syncerus caffer</i> | LC | 109 | 0.90 \pm 0.07 |
| Cetartiodactyla | Bovidae | Bushbuck | <i>Tragelaphus scriptus</i> | LC | 1180 | 0.95 \pm 0.05 |
| Cetartiodactyla | Bovidae | Defassa waterbuck | <i>Kobus ellipsiprymnus defassa</i> | NT | 15 | 0.37 \pm 0.14 |
| Cetartiodactyla | Bovidae | Eland | <i>Tragelaphus oryx</i> | LC | - | - |
| Cetartiodactyla | Bovidae | Kirk's dik-dik | <i>Madoqua kirkii</i> | LC | 53 | 0.30 \pm 0.10 |
| Cetartiodactyla | Hippopotamidae | Common hippopotamus | <i>Hippopotamus amphibius</i> | VU | - | - |
| Cetartiodactyla | Suidae | Common warthog | <i>Phacochoerus africanus</i> | LC | 5 | 0.24 \pm 0.16 |
| Cetartiodactyla | Suidae | Bush pig | <i>Potamochoerus larvatus</i> | LC | 150 | 0.95 \pm 0.05 |
| Perissodactyla | Equidae | Plains zebra | <i>Equus quagga</i> | NT | 1 | 0.05 \pm 0.00 |
| Primates | Cercopithecidae | Olive baboon | <i>Papio anubis</i> | LC | 115 | 0.91 \pm 0.07 |
| Primates | Cercopithecidae | Eastern black and white colobus | <i>Colobus guereza</i> | LC | 7 | 0.48 \pm 0.28 |
| Primates | Galagidae | Greater bushbaby | <i>Otolemur crassicaudatus</i> | LC | 38 | 0.54 \pm 0.12 |
| Proboscidea | Elephantidae | African elephant | <i>Loxodonta africana</i> | VU | 6 | 0.13 \pm 0.10 |
| Rodentia | Hystricidae | Crested porcupine | <i>Hystrix cristata</i> | LC | 52 | 0.62 \pm 0.13 |
| Tubulidentata | Orycteropodidae | Aardvark | <i>Orycteropus afer</i> | LC | 8 | 0.31 \pm 0.17 |

148 *Information obtained from www.iucnredlist.org

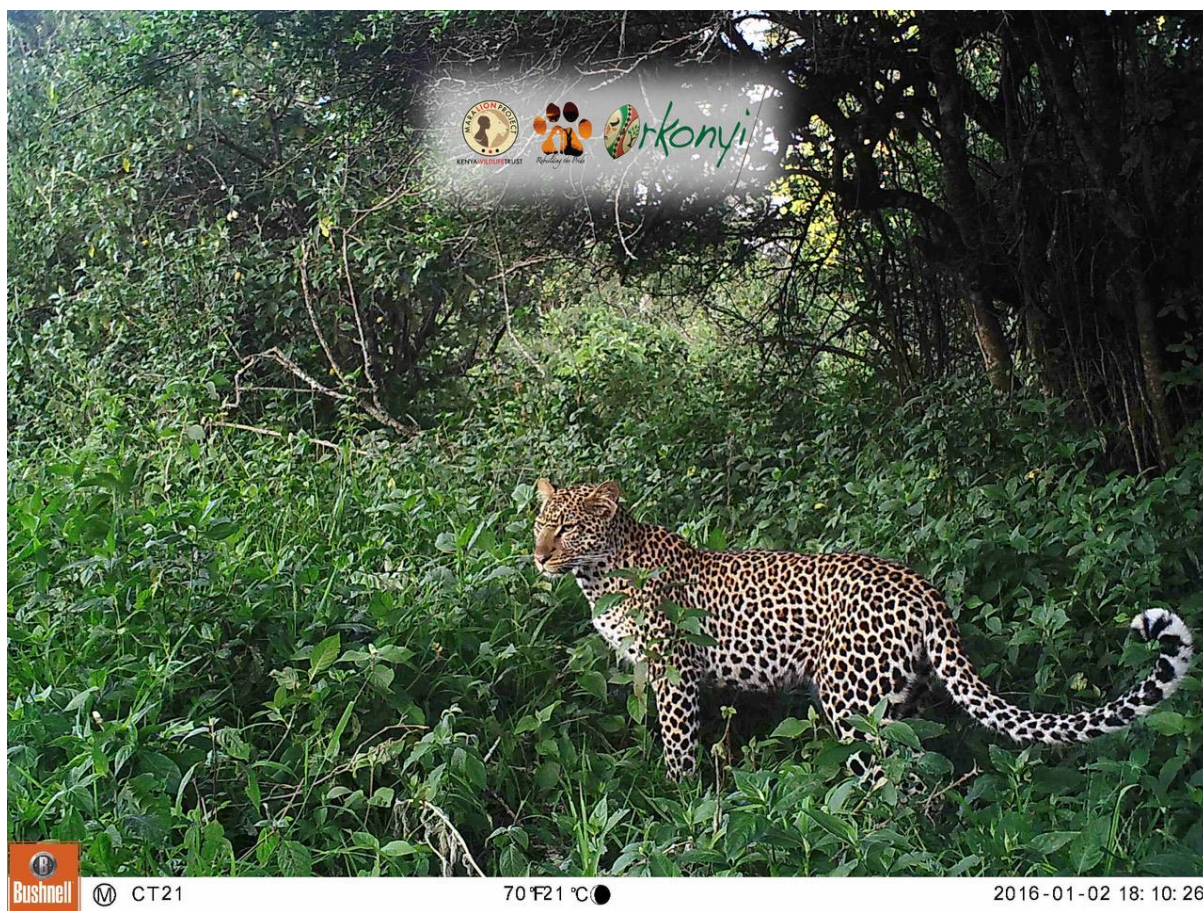
149 [^]LC = Least concern; NT = Near threatened; VU = Vulnerable

Figures

Fig 1 Location of Naimina Enkiyio Forest in the South of Kenya including the locations of the camera traps.



155 Fig 2 Camera-trap image of a leopard in Naimina Enkiyo Forest, Kenya.



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