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A mammal survey of the Serra Jeci Mountain Range, Mozambique, with a review of records from northern Mozambique's inselbergs

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The mountains of northern Mozambique have remained poorly studied biologically until recent years with surveys covering a variety of taxonomic groups highlighting their biological and conservation value. Even so, the medium and large mammal fauna remains poorly known and to date no systematic mammal surveys have been published from any of Mozambique's mountains. We present results of a medium and large mammal survey of Serra Jeci's Mt Chitagal, Mt Sanga and the Njesi Plateau in Niassa, northern Mozambique; the first mammal diversity data collected from these isolated mountains. We recorded 27 mammal species, of which six represent range expansions; Sykes's monkey (*Cercophitecus mitis*), Mozambique dwarf galago (*Paragalago granti*), Smith's red rock hare (*Pronolagus rupestris*), lesser cane rat (*Thryonomys gregorianus*), rock hyrax (*Procavia capensis*) and African buffalo (*Syncerus caffer*). We also reviewed and collated records of medium and large mammals from previously published fieldwork on northern Mozambique's mountains, amounting to a total of 34 large mammal species from seven montane areas, highlighting the lack of mammalian knowledge in Mozambique's Afromontane habitats.

Keywords: Afromontane, camera trapping, *Cercopithecus mitis*, inventory, *Paragalago granti, Pronolagus rupestris*

Introduction

Northern Mozambique is scattered with isolated mountains in a predominantly lowland landscape, which harbour comparatively cooler, wetter climates, typified by Afromontane forest and grasslands (White 1978). The biodiversity of these mountains remained poorly known owing to both the geographic remoteness of northern Mozambique and the Mozambican civil war (1977–1992), which limited access to the region. As this conflict stabilised, a surge in biological survey effort highlighted their biological and conservation importance (Bayliss et al. 2014), in particular that of Mts Mabu, Namuli, Chiperone, Inago, Yao, Mecula, Lico and Ribaue (Timberlake et al. 2007; Timberlake et al. 2009; Bayliss et al. 2010; Bayliss et al. 2010; Monadjem et al. 2010; Timberlake et al. 2012; Bayliss et al. 2014; Bayliss et al. 2016; Conradie et al. 2016) (Figure 1). These recent studies focussed primarily on bats, birds, herpetofauna, botany and butterflies (Spottiswoode et al. 2008; Congdon et al. 2010; Harris et al. 2011; Conradie et al. 2016; Branch et al. 2019), yielding the discovery of several species new to science (Spottiswoode et al. 2008; Branch and Tolley 2010; Congdon et al. 2010; Harris et al. 2011; Taylor et al. 2012; Branch et al. 2014; Daniels et al. 2014; Conradie et al. 2016; Van Velzen et al. 2016). Bayliss et al. (2014) also conclude that the Chiperone-Inago-Namuli-Mabu faunal group appears biogeographically distinct, particularly in butterflies and herpetofauna. This is further corroborated across the Afromontane birds of Mozambique's mountains (Jones et al. submitted), but the necessary data to apply to mammals have not yet been compiled.

Although medium and large mammals (loosely, non-rodent, terrestrial mammals) are some of the better-studied taxa in Africa, their diversity in Mozambique remains poorly known compared with neighbouring countries (Neves et al. 2018). Published mammal surveys of northern Mozambique (broadly north of the Zambezi River) are especially lacking (Schneider et al. 2005) and as a result hamper conservation efforts aiming to protect key regions for mammalian diversity here (Schneider et al. 2005; Neves et al. 2018). Despite the upturn in biological surveys on Mozambique's highlands, limited effort has been placed on mammal surveys and to date no systematic survey results have been reported from any of Mozambique's mountains.

Accordingly, to contribute to a better understanding of the mammalian diversity of Mozambique's mountains we present results of a survey of the medium and large mammal fauna of Mt Chitagal, Mt Sanga and the Njesi Plateau from the Serra Jeci, in Niassa Province. We then also review and collate published mammal records from other inselbergs in Mozambique.

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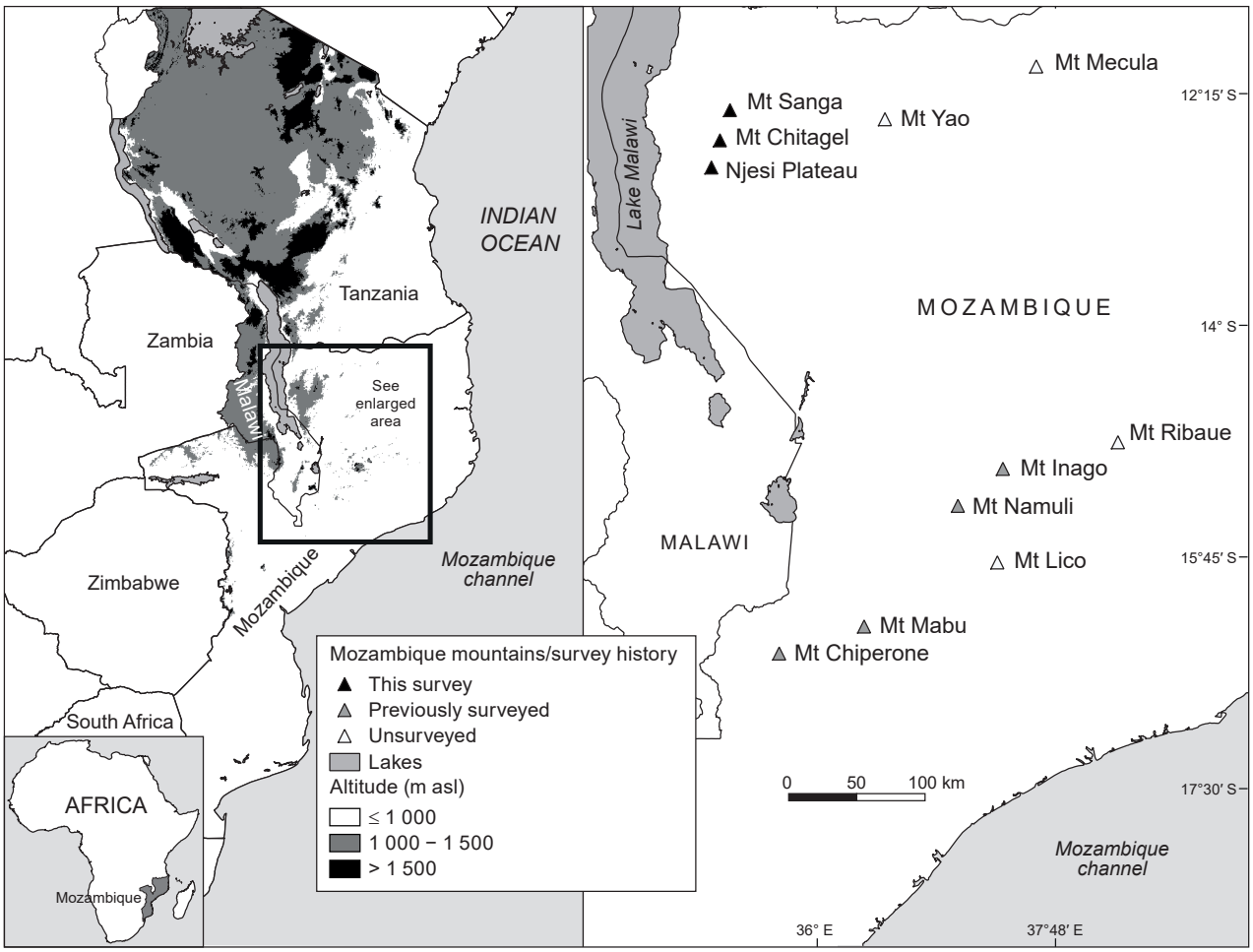

Figure 1: Northern Mozambique's inselbergs with mammal records with our study sites: Mt Sanga, Mt Chitagal and the Njesi Plateau as black triangles, previously surveyed mountains as grey triangles and mountains that have been surveyed for different taxa, but without mammal records, as white triangles. m asl = metres above sea level

Materials and methods

Data collection

As part of a wider biodiversity expedition (Jones et al. 2017) a survey of medium and large mammals was conducted in the Serra Jeci in Mozambique's Niassa Province. We define medium and large mammals hereafter as including all non-rodent and terrestrial mammals. We do so to both make the results from our study as widely applicable to the study of mammals in the region, and because volant mammals (bats) and small mammals, such as small rodents, typically necessitate specific field survey methodologies and often more advanced taxonomic treatment (e.g. see Monadjem et al. 2010). The only exceptions to our distinction are for cane rats (*Thryonomys* sp.) and Gambian pouched rat (*Cricetomys gambianus*), because they are functionally (from a survey sense) more representative of medium and large mammals owing to their size (>1 kg) and squirrels, which are more easily observed and identified from camera traps than caught in traps. Mammal surveys were conducted at the Serra Jeci from 6 to 24 November 2016 (18 survey days), which coincided with the end of the dry season, and included camera trapping and visual encounter surveys. Identifications were aided by Stuart and Stuart (2015) and spoor was identified using Murray (2011) where possible.

Study sites

Three mountain peaks of the Sera Jeci were surveyed: Mt Sanga (1 782 m, 12°23′24″ S, 35°20′5″ E, seven survey days), the Njesi Plateau (1 843 m, 12°36′14″ S, 35°15′15″ E, four survey days) and Mt Chitagal (1 784 m, 12°50′10″ S, 35°11′21″ E, seven survey days) (Figure 1). All three sites contain a mosaic of tall and short Afromontane grassland, interspersed with rocky outcrops and patches of evergreen Afromontane and riverine forest on the higher slopes and gullies. Although the forest patches on Mt Sanga and Mt Chitagal consist of closed canopy forest, those at the Njesi Plateau were characterised by dense tall grasslands interspersed with low and open canopy scrub. At lower altitudes the mountains are typified by extensive miombo woodland with occasional intergrade zones of mixed woodland types at higher altitudes. More specific information on the study sites can be found in Jones et al.

(2017). Notes were also made on anthropogenic pressures on the mountains, based on human disturbance (e.g. deforestation) and evidence of hunting (e.g. snares).

Survey methods

Camera trapping

Remotely-triggered Bushnell camera traps (Trophy Cam HD 2012 and 2015 models, Aggressor HD 2016 model) were deployed for a total of 34 trap days (14 cameras, 1 421–1 681 m asl [metres above sea level]) on Mt Chitagal, 38 camera trap days (10 cameras, 1 650–1 777 m asl) on Mt Sanga and 36 trap days on the Njesi Plateau (12 cameras, 1 768–1 841 m asl). Cameras were placed in a semi-structured way (Tobler et al. 2008), at around 40 cm above the ground and aimed parallel to the ground to optimise detection of medium and large terrestrial mammals (Otis et al. 1978; Williams et al. 2002; Tobler et al. 2008), primarily targeting non-arboreal and non-aquatic/riverine species. Most cameras were placed in forest patches in locations assumed to be frequented by mammals, such as trails and drinking locations. Cameras were set to take a series of three photos when triggered, without delay between triggers.

Visual encounter surveys, opportunistic observations and spoors

Diurnal and nocturnal visual encounter surveys were conducted aimed at visiting as many habitats and covering as much terrain as possible, taking activity patterns for different species into account. Each survey was conducted by two or three observers walking at a slow pace and scanning all layers of the vegetation, aided by binoculars and LED head and hand torches at night. Opportunistic records and observations during other biological surveys (see Jones et al. 2017) were included when photographic evidence was provided. Spoor identification, including dung, quills and prints, were only included where identification was unambiguous.

Comparison with known distributions and other studies

The species recorded during our survey were compared with known distributions derived from the IUCN Red List 2018-2 (IUCN 2018) and distribution records listed in GBIF (GBIF.org 2017) to establish whether records from this survey constituted significant range extensions. To provide a more complete picture of the known medium and large mammal fauna on northern Mozambican inselbergs, mammal records from other inselbergs in the region were also compiled by conducting an exhaustive literature search (both scientific papers and expedition reports).

Results

Survey results

We recorded 24 medium and large mammal species from the Serra Jeci's Mount Chitagal (*n* = 17), Mount Sanga (*n* = 17) and Njesi Plateau (*n* = 7) (Table 1), belonging to seven orders: Primates (*n* = 5), Lagomorpha (*n* = 1), Rodentia (*n* = 3), Carnivora (*n* = 9), Hyracoidea (*n* = 1), Suiformes (*n* = 1) and Cetartiodactyla (*n* = 3). Of these, five species were recorded on all three mountains; bushpig (*Potamochoerus larvatus*), African civet (*Civettictis civetta*), common large-spotted genet (*Genetta maculata*), spotted hyena (*Crocuta crocuta*) and Gambian pouched rat (*Cricetomys gambianus*).

Following IUCN species distribution data (IUCN 2018), 45 medium and large mammal species may be expected to occur here. Of these, 18 (40%) were recorded in our survey. We recorded six species that represent extensions to their known IUCN distributions; Sykes's monkey (*Cercophitecus mitis moloneyi*), Mozambique dwarf galago (*Paragalago granti*), lesser cane rat (*Thryonomys gregorianus*), Smith's red rock hare (*Pronolagus rupestris*), rock hyrax (*Procavia capensis*) and African buffalo (*Syncerus caffer*).

Comparing survey methods, 12 species were recorded through visual encounter surveys (nine on Chitagal, nine on Sanga and two on Njesi), 11 species were confirmed through spoor observation (eight on Chitagal, eight on Sanga and four on Njesi) and eight species were recorded through camera trapping (five on Chitagal, six on Sanga and five on Njesi). The common large-spotted genet was the most frequently recorded species on camera traps (six events from four camera stations on Mt Chitagal; one from a single camera station on Mt Sanga and three from three camera stations on the Njesi Plateau). African palm civet (*Nandinia binotata*) was the most commonly recorded species during visual encounter surveys, although it was not recorded at the Njesi Plateau, where they were exclusively observed on high tree branches during night surveys in Afromontane forest patches.

During spoor surveys, the most commonly identified dung belonged to bushpig, rock hyrax (*Procavia capensis*), klipspringer (*Oreotragus oreotragus*) and African buffalo. A variety of dung from other herbivores was also observed, but could not be identified with certainty. Partly-overgrown elephant (*Loxodonta africana*) trails were also recorded in montane forest patches near the summit of Mt Chitagal, although elephants have reportedly not been seen since 2012, according to our local guides.

Evidence of hunting was also present on the Serra Jeci. More than 30 snares were observed on the Njesi Plateau. Each snare was set in, or on the edge of, forested areas and consisted of two types: a bent twig driven in the ground with a noose made of plastic string was set on small trails and appeared to be made to catch terrestrial birds and small mammals such as rodents or a trip snare with the noose on the ground, seemed capable to trap larger species, such as small antelopes and bushpigs. One trip snare and a small hunting camp, in which the skull of an African buffalo was found, were also observed on Mt Chitagal. No evidence of hunting was observed on Mt Sanga.

Range extensions

Sykes's monkey (Cercophitecus mitis moloneyi) *(Wolf, 1822)*

One troop of at least three and one troop of at least six individuals were observed in montane forest on Mt Sanga (1 660 m asl) and in riparian forest on Mt Chitagal respectively. A single individual was recorded on camera trap (1 412 m asl) while drinking from a small stream on Mt Chitagal (Figure 2). The reddish colouration on the dorsum indicates the subspecies *C. m. moloneyi*. The nearest known distribution of *C. mitis* is 130 km to the west

Table 1: Large mammal species recorded on different mountains in northern Mozambique, with significant range extensions in bold. E = Locally Extinct/Historical Record. H = Hunter Record/ Local Knowledge, V = Visual Record, C = Camera Trap, S = Spoor/Faeces, x = Occurrence Record. LC = Least Concern, VU = Vulnerable, EN = Endangered, NT = Near Threatened.

	Common Name	Scientific Name	Authority	This survey								This survey		IUCN status
				Chitagal	Njesi	Sanga	Mabu	Namuli	Chiperone	Inago	Expected on Serra Jeci	Elevation (masl)	Survey method	
Primates														
	Mozambique dwarf galago	*Paragalago granti*	(Thomas and Wroughton, 1907)	x		x	x	x	H			1 670	V	LC
	Sykes's monkey	*Cercopithecus mitis*	Wolf, 1822	x		x	x	x	H	x		1 450	V	LC
	thick-tailed galago	*Otolemur crassicaudatus*	(ÉG Saint-Hilaire, 1812)			x	x				x	1 156	V	LC
	vervet monkey	*Chlorocebus pygerythrus*	(F Cuvier, 1821)	x			x	H	H		x	1 450	V	LC
	yellow baboon	*Papio cynocephalus*	(Linnaeus, 1766)	x			x		x		x	600	V	LC
Pholidota														
	Temminck's ground pangolin	*Smutsia temminckii*	(Smuts, 1832)								x			VU
Lagomorpha														
	Savanna hare	*Lepus victoriae*	Thomas, 1893								x			LC
	Smith's red rock hare	*Pronolagus rupestris*	(A Smith, 1834)			x	x	x		x		1 710	C, S, V	LC
Rodentia														
	African porcupine	*Hystrix africaeaustralis*	Peters, 1852	x	x				H		x		S	LC
	Smith's bush squirrel	*Paraxerus cepapi*	(A. Smith, 1836)					H						LC
	Gambian giant pouched rat	*Cricetomys gambianus*	Waterhouse, 1840	x	x	x					x	1 030	V, C	LC
	mutable sun squirrel	*Heliosciurus mutabilis*	(Peters, 1852)	x			x	H			x		V	LC
	lesser cane rat	*Thryonomys gregorianus*	(Thomas, 1894)	x		x						1 618	S	LC
	Vincent's bush squirrel	*Paraxerus vincenti*	Hayman, 1950					H						EN
Carnivora														
	African civet	*Civettictis civetta*	(Schreber, 1776)	x	x	x					x		C, S	LC
	African clawless otter	*Aonyx capensis*	(Schinz, 1821)								x			NT
	African palm civet	*Nandinia binotata*	(Gray, 1830)	x		x					x		V	LC
	African striped weasel	*Poecilogale albinucha*	(Gray, 1864)					H			x			LC
	African wild cat	*Felis silvestris*	Schreber, 1777								x			LC
	banded mongoose	*Mungos mungo*	(Gmelin, 1788)					x			x			LC
	bushy-tailed mongoose	*Bdeogale crassicauda*	Peters, 1852								x			LC
	caracal	*Caracal caracal*	(Schreber, 1776)								x			LC
	common large-spotted genet	*Genetta maculata*	(Gray, 1830)	x	x	x		H			x	1 400–1 600	C, V	LC
	dwarf mongoose	*Helogale parvula*	(Sundevall, 1847)			x					x	1 740	S	LC
	Egyptian mongoose	*Herpestes ichneumon*	(Linnaeus, 1758)								x			LC
	leopard	*Panthera pardus*	(Linnaeus, 1758)			x	x	E	x	H			S	VU
	lion	*Panthera leo*	(Linnaeus, 1758)								x			VU
	Meller's mongoose	*Rhynchogale melleri*	(Gray, 1865)								x			LC
	ratel (badger)	*Mellivora capensis*	(Schreber, 1776)								x			LC
	serval	*Leptailurus serval*	(Schreber, 1776)					x			x			LC
	side-striped jackal	*Canis adustus*	Sundevall, 1847		x						x	1 804	C	LC

Table 1: (cont.)

	Common Name	Scientific Name	Authority	This survey			Mabu	Namuli	Chiperone	Inago	Expected on Serra Jeci	This survey		IUCN status
				Chitagal	Njesi	Sanga						Elevation (m asl)	Survey method	
	slender mongoose	*Herpestes sanguineus*	(Rüppell, 1835)	x				x			x		C	LC
	spotted hyena	*Crocuta crocuta*	(Erxleben, 1777)	x	x	x					x		S	LC
	striped polecat	*Ictonyx striatus*	(Perry, 1810)					H	H		x			LC
	water mongoose	*Atilax paludinosus*	(G Cuvier, 1829)	x							x	1 156	S	LC
	white-tailed mongoose	*Ichneumia albicauda*	(G Cuvier, 1829)								x			LC
Tubulidentata														
	aardvark	*Orycteropus afer*	(Pallas, 1766)								x			LC
Hyracoidea														
	rock hyrax	*Procavia capensis*	(Pallas, 1766)	x		x	x		H				V	LC
	southern tree hyrax	*Dendrohyrax arboreus*	(A Smith, 1827)								x			LC
	yellow-spotted rock hyrax	*Heterohyrax brucei*	(Gray, 1868)				x	x		x	x			LC
Suiformes														
	bushpig	*Potamochoerus larvatus*	(F Cuvier, 1822)	x	x	x	x	E,H	H		x		C, S	LC
	common warthog	*Phacochoerus africanus*	(Gmelin, 1788)								x			LC
Cetartiodactyla														
	African buffalo	*Syncerus caffer*	(Sparrman, 1779)	x					H			1 700	S, V	LC
	blue duiker	*Philantomba monticola*	(Thunberg, 1789)				x	x			x			LC
	bushbuck	*Tragelaphus scriptus*	(Pallas, 1766)				x	H	H		x			LC
	common duiker	*Sylvicapra grimmia*	(Linnaeus, 1758)								x			LC
	common eland	*Tragelaphus oryx*	(Pallas, 1766)								x			LC
	greater kudu	*Tragelaphus strepsiceros*	(Pallas, 1766)								x			LC
	klipspringer	*Oreotragus oreotragus*	(Zimmermann, 1783)			x	x	H			x	1 700	C, V	LC
	Natal red duiker	*Cephalophus natalensis*	A Smith, 1834				H	H				–		LC
	sable antelope	*Hippotragus niger*	(Harris, 1838)	x		x					x	600	S	LC
	Sharpe's grysbok	*Raphicerus sharpei*	Thomas, 1897								x			LC
	southern reedbuck	*Redunca arundinum*	(Boddaert, 1785)								x			LC
	suni	*Nesotragus moschatus*	Von Dueben, 1846								x			LC
	waterbuck	*Kobus ellipsiprymnus*	(Ogilbyi, 1833)								x			LC

in Malawi, 55 km to the south in Mozambique and 390 km to the east in Tanzania (Kingdon et al. 2013) (see Figure 2). This species has also been recorded as isolated populations on Mt Inago (Bayliss et al. 2010), Mt Mabu (Timberlake et al. 2012) and Mt Namuli (Dowsett-Lemaire 2008).

Mozambique dwarf galago (Paragalago granti) (Thomas and Wroughton, 1907)

Two pairs of two Mozambique dwarf galago were observed on Mt Chitagal and Mt Sanga (Figure 3). Both pairs were recorded on the edge of Afromontane forest

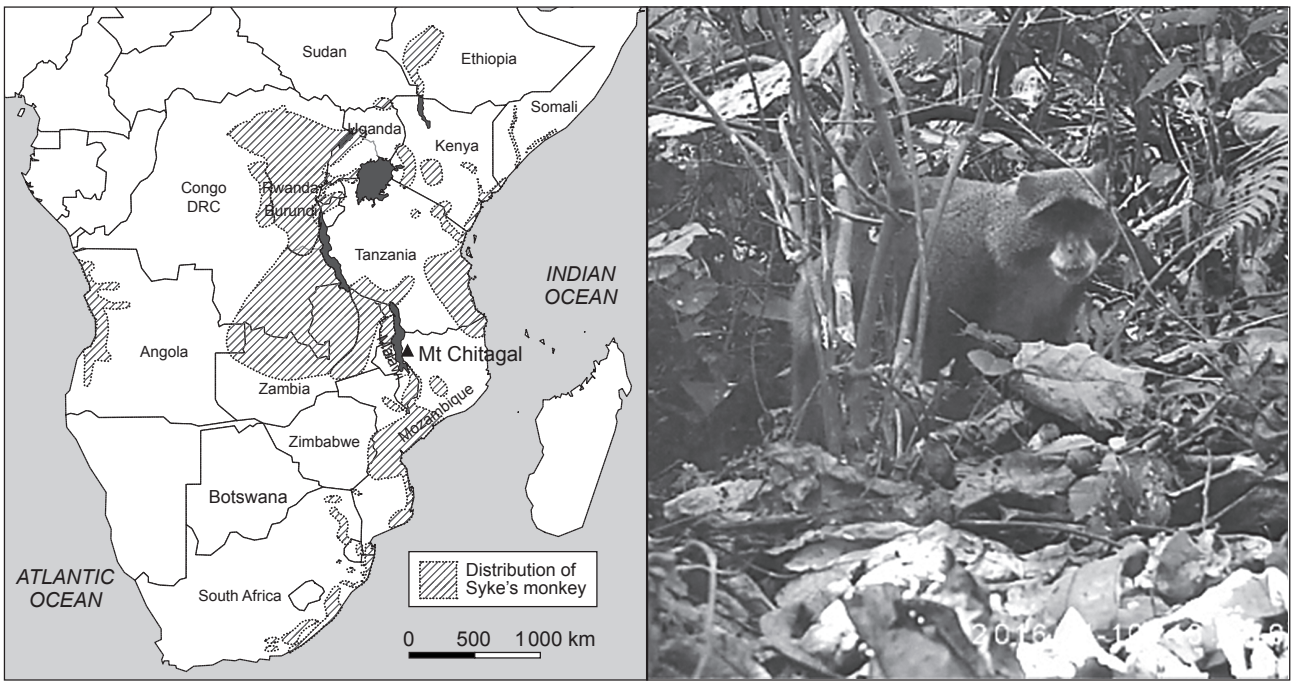

Figure 2: IUCN distribution map (Kingdon et al. 2008) of Sykes's monkey (*Cercopithecus mitis moloneyi*), including the location of Mt Chitagal (left). Camera trap image of *C. mitis moloneyi* drinking from a small stream at Mt Chitagal (right).

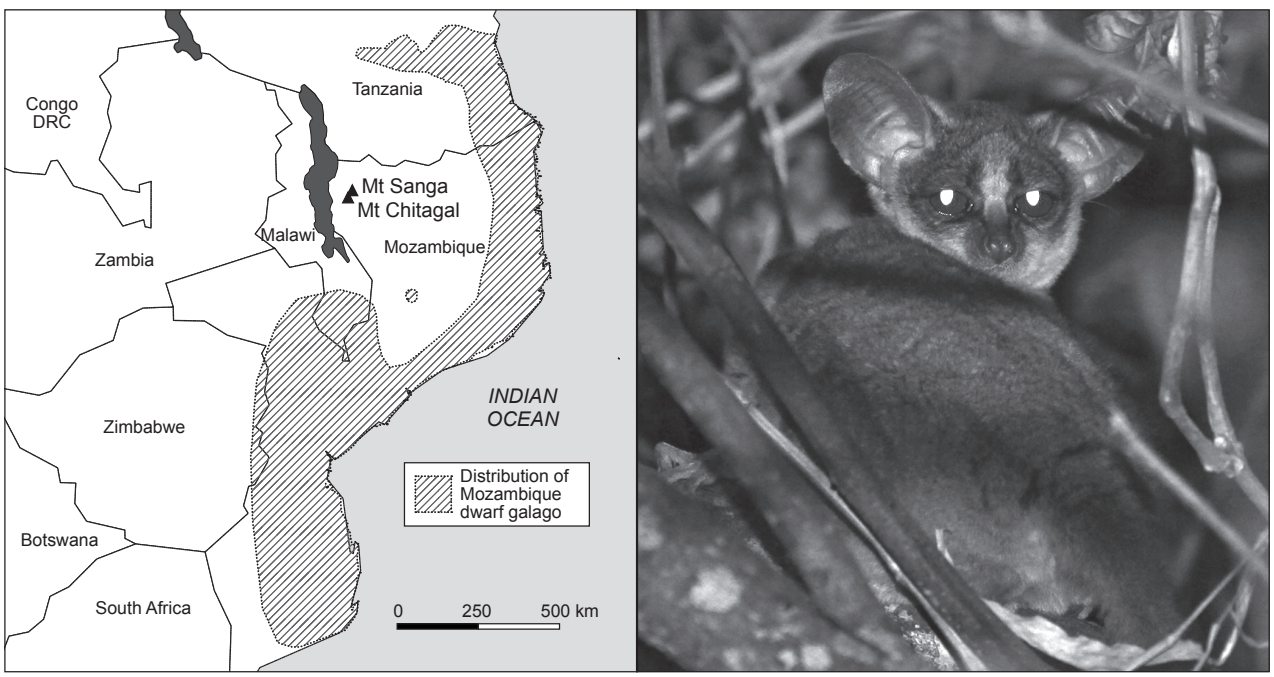

Figure 3: IUCN distribution map (Honess 2008) of the Mozambique dwarf galago (*Paragalago granti*), including the location of Mt Sanga and Mt Chitagal. Photograph of *P. granti* on the edge of Afromontane forest on Mt Sanga (right)

patches near the mountains' summits at night. *P. granti* was also recently recorded from Mts Chiperone, Namuli and Mabu (Timberlake et al. 2007; Timberlake et al. 2009; Timberlake et al. 2012). The species was identified by its disproportionally large ears and its face mask, ruling out any other species that could potentially occur here. Previously, this species was only known from coastal areas in northern Mozambique and mountains in central Mozambique. The nearest verified records occur in southern Malawi, around the Blantyre area (Butynski et al. 2006)

Lesser cane rat (Thryonomys gregorianus) *(Thomas, 1894)*
The skull of a juvenile was collected (deposited at the Zoological Research Museum Alexander Koenig, Bonn, Germany; deposit number ZFMK-2018.0700) from montane grassland bordered by two woodland patches at 1 618 m asl on the ridge of Mt Sanga (Figure 4). The skull was incomplete and partly burnt. Identification was based on grooved incisors and skull shape, with skull differing from the closely related greater cane rat (*Thryonomys swinderianus*) in all identifying features that were still distinguishable from the incomplete skull, particularly the position of grooves on the teeth, as described by van der Merwe (2007) and Monadjem et al. (2015). In addition, pellets believed to belong to this species were collected from Mt Sanga, as well as from Mt Chitagal (Figure 4). *T. gregorianus* has only been recorded three times in Mozambique (Neves et al. 2018), two of which were from the Namuli Massif (Grant 2017).

Smith's red rock hare (Pronolagus rupestris) *(Smith, 1834)*
Smith's red rock hare (Figure 5) was recorded twice on a single camera trap at 1 430 m asl on Mt Sanga and on four occasions during diurnal surveys. These records constitute a substantial range expansion and the northernmost record in Mozambique (Figure 5). The latest IUCN distribution map shows its nearest area of occurrence to be in Malawi ~160 km to the east, or 350 km to the north in Tanzania (Kingdon et al. 2008) (see Figure 2). Recent observations also confirmed Smith's red rock hare 365 km south of Mt Sanga, on Mt Inago (Bayliss et al. 2010). The species has also been recorded south of Mt Inago on Mt Mabu (Bayliss et al. 2014) and Mt Namuli (Timberlake et al. 2009), making our records the fourth locality in Mozambique.

Rock hyrax (Procavia capensis) *(Pallas, 1766)*
One or more groups of rock hyrax were observed on multiple occasions at a single location on Mt Sanga and on one location on Mt Chitagal (Figure 6). Both groups were observed on rocky outcrops with burrows at the top of the mountains. Dung was visible in multiple locations. These records are 194 km north of the southernmost known population and 966 km south of the northernmost populations (Butynski et al. 2015) (Figure 6).

African buffalo (Syncerus caffer) *(Sparrman, 1779)*
A single herd consisting of three adult and one juvenile African buffalo was observed in tall grassland near the summit of Mt Chitagal. Several piles of dried dung, numerous prints in grassland on the higher slopes and a buffalo skull in a hunter camp were also encountered on the mountain. The historical range of African buffalo included the area, but in northern Mozambique it is thought to solely survive in and around the Niassa Game Reserve, some 63 km to the east (IUCN SSC Antelope Specialist Group 2008) (Figure 7).

Comparison with other northern Mozambican mountains

Our review of published literature yielded seven reports and articles with records of 23 mammal species from other

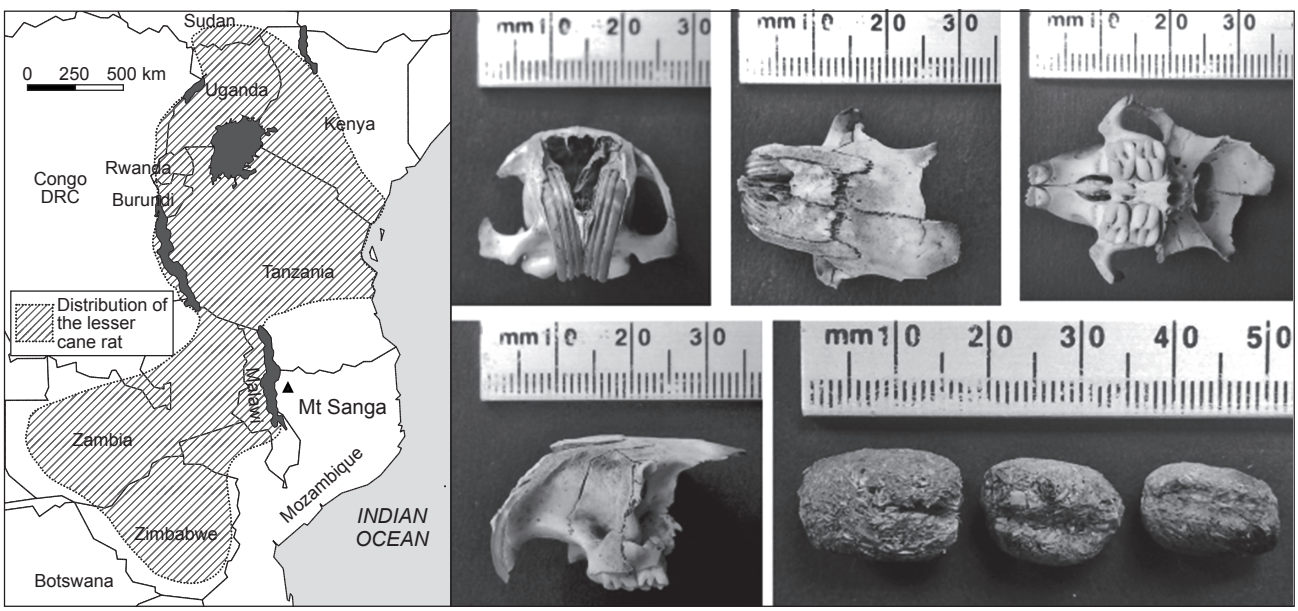

Figure 4: IUCN distribution map (Cassola 2017) of the lesser cane rat (*Thryonomys gregorianus*), including the location of Mt Sanga. Skull and pellet images collected from Mt Sanga (right)

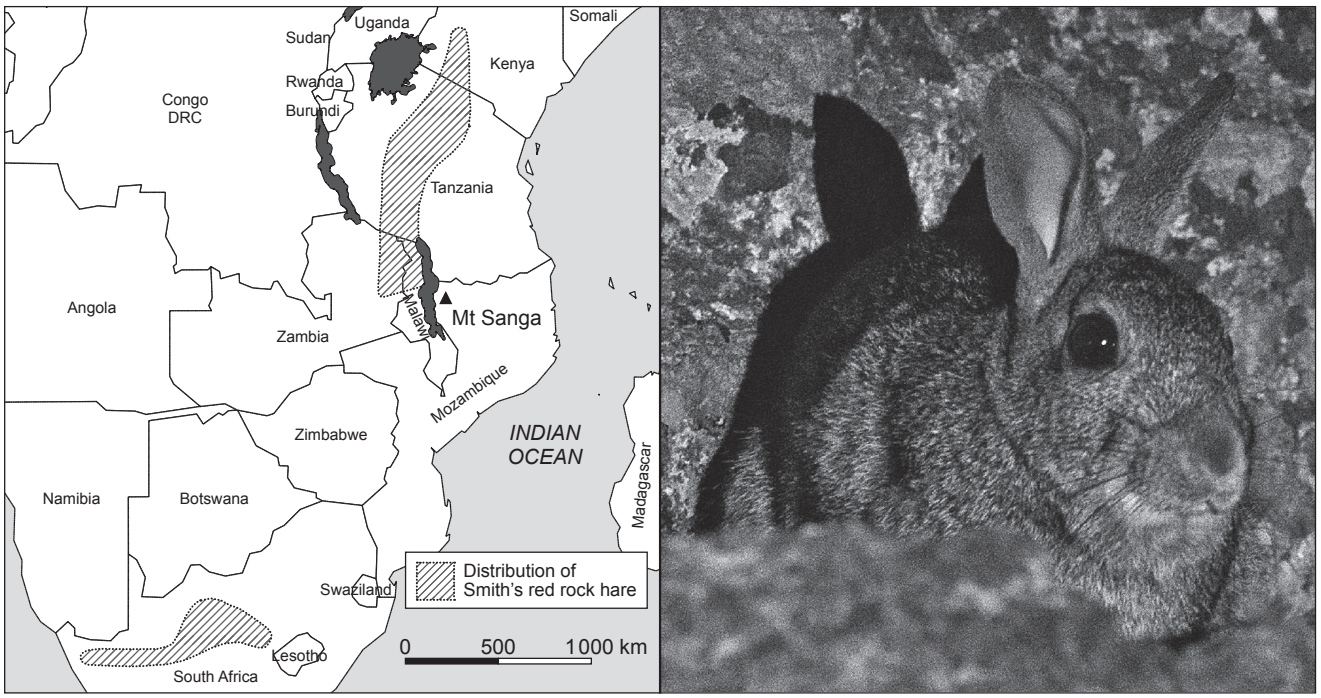

Figure 5: IUCN distribution map (Smith and Boyer 2008) of Smith's red rock hare (*Pronolagus rupestris*, including its location, Mt Sanga (left), and the species observed at night on the higher slopes of Mt Sanga (right)

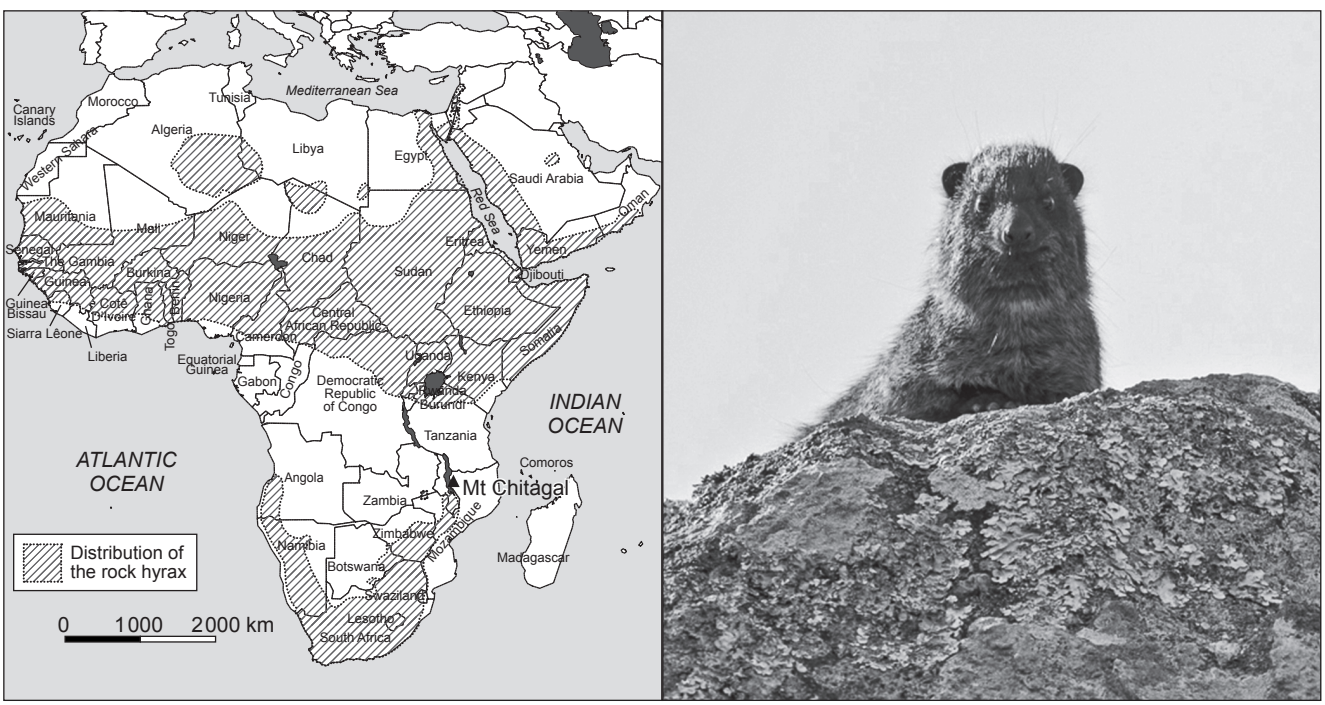

Figure 6: IUCN distribution map (Butynski et al. 2015) of the rock hyrax (*Procavia capensis*), including the location of Mt Chitagal (left). *P. capensis* observed on rocky outcrops at the summit of Mt Chitagal (right). The record constitutes a range expansion.

Mozambican mountains; Mt Mabu (*n* = 14), Mt Namuli (*n* = 15), Mt Chiperone (*n* = 11) and Mt Inago (*n* = 2) (Table 2), belonging to the same orders as those recorded in this survey. Combined with our records these amount to 34 medium and large mammal species on seven inselbergs in northern Mozambique (Table 1). However, many of the records in the reviewed literature are anecdotal as medium and large mammals have not been subject to systematic

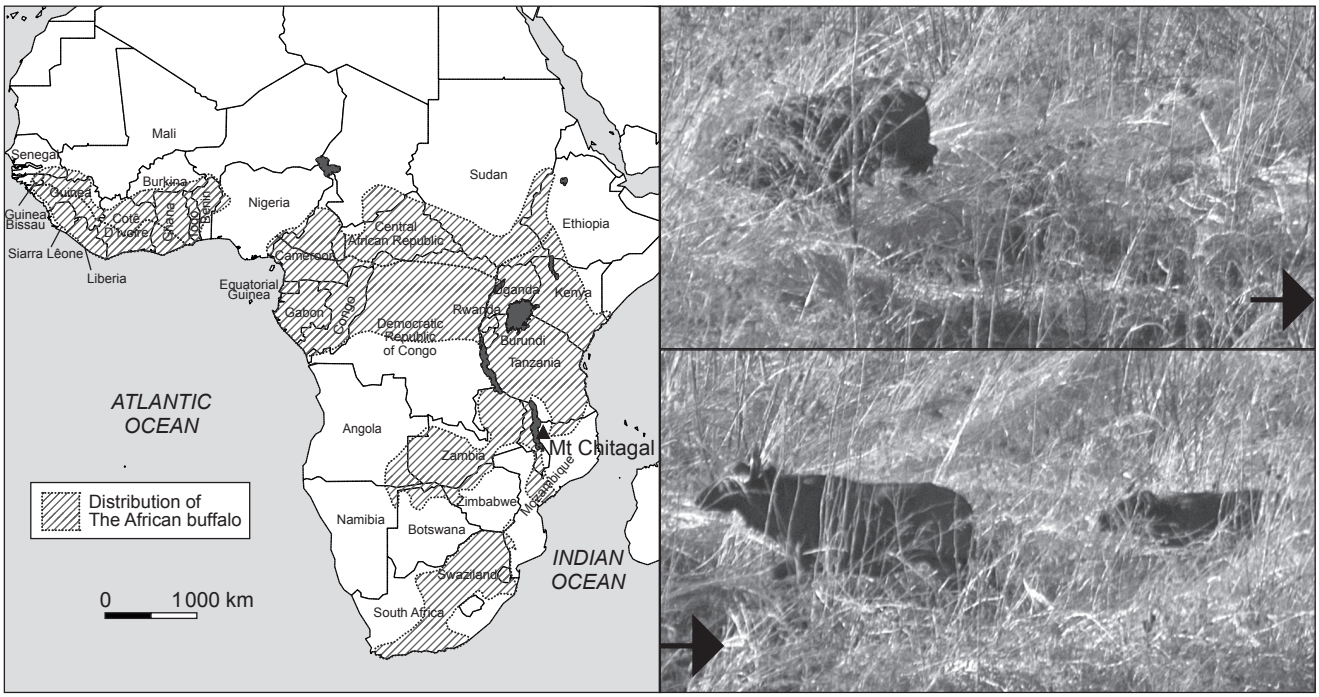

Figure 7: IUCN distribution map (IUCN SSC Antelope Specialist Group 2008) of African buffalo (*Syncerus caffer*), including the location of Mt Sanga (left). A group three individuals was observed near the summit of Mt Chitagal (right)

Table 2: Mountains in northern Mozambique with known mammal records

Mountain	Elevation (m asl)	Coordinates	Reference	Survey days	Survey dates	Methods employed
Inago	1 703	15°2′42″ S, 37°23′46″ E	Bayliss et al. (2010)	3 (recce), 10 (main survey)	27–29 May 2008 4–13 May 2009	Opportunistic observations
Mabu	1 710	16°17′56″ S, 36°23′44″ E	Bayliss et al. (2014b), Dowsett-Lemaire et al. (2009), Timberlake et al. (2012)	>50	Dec 2005, Jan 2006, Sep–Oct 2008, May 2009, Oct-Dec 2010, October–November 2012, October 2013, March 2017	Opportunistic observations, Local hunter records
Namuli	2 419	37°03′ E, 15°22′ S	Dowsett-Lemaire (2008), Timberlake et al. (2009)	>30	2005, May and 14–26 Nov 2007	Opportunistic observations
Chiperone	2 054	16°28′44 S, 35°42′88″ E	Timberlake et al. (2007)	14	22 Nov–5 Dec 2006	Opportunistic observations, Local hunter records

surveys and records include second-hand data obtained by interviews with local hunters and villagers. In addition, an ornithological survey on the Njesi Plateau in 2001 reported presence of African elephant tracks and dung (Ryan and Spottiswoode (2003). These authors also noted the presence of lion (*Panthera leo*), leopard (*Panthera pardus*), eland (*Taurotragus oryx*), sable antelope (*Hippotragus niger*) and zebra (*Equus crawshayi*) to be reported by local people. We did not include these accounts in our summary table, because we could not verify the specific localities of these records from the mountains themselves.

Discussion

We recorded 24 medium and large mammal species from Mt Chitagal, Mt Sanga and the Njesi Plateau, of which six were range extensions. These range extensions are mostly of common species, but illustrate the lack of knowledge of the mammal fauna in northern Mozambique. The relatively low number of mammal species recorded (39% of mammal species expected to occur here, plus six range extensions) is likely an artefact of two factors. Firstly, our survey was time-restricted and effort was limited to 4 to 7 survey days

per mountain, and secondly, the seasonal timing of our surveys when conditions at the study sites were very dry at the end of the dry season.

Water availability is a likely factor determining the potential mammal assemblage on these mountains, with grazers being especially reliant on water (Western 1975) and unlikely to be present when this is absent. During our survey a very small amount of flowing water was present in a gully on the Njesi Plateau, as well as a larger stream on Mt Chitagal. Records of African buffalo indicate that the stream on Mt Chitagal can sustain grazers. Further evidence of large numbers (specifically footprints) of grazers likely occurring in the wet season was also evident at this stream. Only one other large grazer, sable antelope (*Hippotragus niger*), was recorded and only on the lower slopes (~600 m asl) of Mt Chitagal and Mt Sanga. Other large grazers may be present on the mountains in the wet season only when water and young shoots become available (Fryxell and Sinclair 1988). Large quantities of dung piles and pugmarks from several unidentified herbivore species were present on both Mt Sanga and Mt Chitagal, often in miombo woodland at lower elevations. However, the dominance of tall rather than shorter grasses at higher elevations, a potential result of lack of grazing, on all three mountains could suggest this group is not present, at least not in significant numbers (McNaughton et al. 1988).

Comparison with other studies

Records for 23 mammal species on Mts Mabu, Namuli, Chiperone and Inago were collated from the literature, resulting in a total of 34 medium and large mammal species from seven mountains in northern Mozambique (Figure 1). The discrepancy in the number of species recorded between the Serra Jeci and other Mozambican mountains from published literature (Table 1) is almost certainly a reflection of survey effort and methods employed. Although Mt Chitagal, Mt Sanga and the Njesi Plateau were surveyed specifically for medium and large mammals using camera traps and visual encounter surveys, records from Mts Mabu, Namuli, Chiperone and Inago were derived from incidental observations and interviews with local hunters. It is almost certain that more medium and large mammal species occur on these mountains than recorded so far, and we encourage surveys targeting these species.

Although camera traps are a valuable survey method, the use of additional methods in conjunction may also help obtain a more thorough overview of the mammal fauna on these mountains. For instance baiting camera traps could increase trapping rates of mesocarnivores (Moruzzi et al. 2002; Satterfield et al. 2017), whereas the collection and analysis of dung would help identify additional species, particularly herbivores.

Because of the relative lack of survey data available from other surveys, no meaningful biogeographic comparisons are possible with the data at present.

Hunting pressure

Subsistence hunting provides an important component of the diet of local communities (Juste et al. 1995; Fusari and Carpaneto 2006), affecting mammal distributions in Africa (Caballos and Ehrlich 2002). In general, proximity to people increases hunting pressure in an unprotected landscape and highland areas typically receive lower hunting pressure, because they are less accessible (Zafra-Calvo et al. 2018). However, the apparent absence of medium and large mammals (e.g. large herbivores) from our study may well be (partially) owing to hunting. We recorded the highest number of snares (n > 30) at the survey site that was the most accessible and nearest to human habitation (the Njesi Plateau) coinciding with the lowest number of mammal species. By contrast, the highest mammal diversity recorded was on Mt Sanga, where no sign of hunting was observed. Mt Sanga is also considered sacred by the local community (van Berkel, pers. obs.), which probably affords its wildlife an additional level of protection. We note, however, that even remote highlands are not totally free from human disturbance. This is further evidenced by high past and current hunting pressure on other Mozambican highlands, including Mt Inago, Mt Namuli and Mt Mabu. On these mountains, hunting has been reported to be the main reason for the lack of medium and large mammals present (Timberlake et al. 2009; Bayliss et al. 2010; Timberlake et al. 2012).

Future studies

This study, although far from comprehensive, illustrates the merits of short field surveys to better document mammalian distributions, but a more comprehensive understanding is desirable from a conservation perspective. This would require a more structured and larger survey effort, which has a variety of logistical challenges and possibly prohibitive costs meaning its widespread application is unlikely. Despite the time shortfall of rapid surveys for medium and large mammals, conducting similar surveys on northern Mozambique's highland and adjacent lowland areas in different seasons can still provide valuable knowledge to our current understanding of medium and large mammal migration patterns between these areas. A better understanding of the interactions between adjacent high- and lowland habitats has key conservation implications because, irrespective of habitat differences, mountains are not completely isolated from their surroundings. Inselbergs, such as the Serra Jeci, may represent important mammalian refugia, as long as poaching and forest degradation can be prevented.

Water availability is a key resource that likely determines the presence of mammals, especially grazers, on the mountains. This makes the remaining patches of Afromontane and gallery forest on the surveyed mountains particularly important, because trees increase water retention and can prolong water availability into the dry season. Logging and human induced burning should therefore be kept under control. We hope the publication of our survey results encourages more surveys and long-term mammalian studies on Mozambique's Afromontane mammal fauna. Priority survey areas should include the most extensive montane forests in Mozambique, such as Mts Mabu, Namuli and Chiperone, as well as Mt Ribaue in north-central Mozambique and the remote highlands of north-western Niassa, which contain blocks of forest that remain little studied and may harbour important mammalian populations.

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