



MAMMAL DIVERSITY OF AN URBANISED ENVIRONMENT IN AN ARID ZONE OF SOUTH-WEST AFRICA

Grzegorz Kopij 

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Affiliations

Wrocław University of Environ-
mental and Life Sciences
(Wrocław, Poland)

Correspondence

Grzegorz Kopij; Wrocław Univer-
sity of Environmental and Life
Sciences, 5b Kozuchowska Street,
51-631 Wrocław, Poland; Email:
gregorius.kopijus@gmail.com;
orcid: 0000-0001-7614-1983

Abstract

Thorough investigation of the entire mammalian assemblages has not been hitherto conducted in any African city. Most studies were limited to single species causing problems to citizens or to small mammals causing health hazard. In 2011–2020, 81 mammal species were recorded in Windhoek, the capital of Namibia, although only 34 (42.0%) species occurred in the inner zone of the city (50 km²). The most speciose (25 species) order were rodents. Within this order the most speciose was the family Muridae (n = 13 species), while the most common rodent species were: *Rhabdomys pumilio*, *Mastomys coucha*, *Gerbilliscus leucogaster*, and *Gerbillurus paeba*. The second most speciose group of mammals were Chiroptera represented by 14 (17.3%) species in the outer zone (650 km²) and 8 species (23.5%) in the inner zone. Ungulates, although mostly rare or uncommon, were in the outer zone represented by eight (9.9%) species. None was, however, recorded in the inner zone. Nineteen Carnivora species (23.5%) were recorded in the outer zone, but only two of them in the inner zone. Other species recorded in Windhoek were representatives of seven other orders: Eulipotyphla (n = 4 spp.), Macroscelidea (n = 3), Lagomorpha (n = 3), Hyracoidea (n = 1), Primates (n=2), Tubulidentata (n = 1), and Pholidota (n = 1). Two species, *Cynictis penicillata* and *Geosciurus inauris*, were found to be relatively common in the inner zone. They have reached a population density (5.6 and >2.0 individuals per 100 ha, respectively) higher than in any other cities in Namibia, and probably in southern Africa at large. Despite intense searching in the inner zone, *Hystrix africaustralis* and *Procavia capensis* were only recorded in a shrubby hill. The *Procavia capensis* population was estimated at 40–70 individuals. A few troops of *Papio ursinus* are resident only in the outer zone. The following species recorded in Windhoek are in the IUCN Red List of Threatened Species: *Acinonx jubatus*, *Panthera pardus*, *Felis nigripes*, *Hyaena brunnea*, and *Smutia temminckii*. Noteworthy is the absence of any alien mammal species in the inner zone, and the presence of only *Mus musculus* in the outer zone of the city. The protection of mammals in Windhoek, especially in the outer zone, may act as a catalyst to move the municipality governance towards a more effective biodiversity conservation.

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Різноманіття ссавців урбанізованого середовища в посушливій зоні південно-західної Африки

Гжегож Копій

Резюме. Досі в жодному африканському місті не проводилося ретельного дослідження всіх ссавців. Більшість досліджень обмежувалися окремими видами, що створюють проблеми для громадян, або дрібними ссавцями, що становлять загрозу для здоров'я. У 2011–2020 роках у Віндгуку, столиці Намібії, зареєстровано 81 вид ссавців, хоча лише 34 види (42,0%) зустрічалися у внутрішній зоні міста. Найбільш видоспецифічним (21 вид) рядом були гризуни. У межах цього ряду найбільш видоспецифічною була родина Muridae (n = 7 видів), а найпоширенішими видами серед гризунів були *Rhodomys pumilio*, *Mastomys coucha*, *Gerbilliscus leucogaster* і *Gerbillurus paeba*. Другою найбільш видовою групою ссавців були рукокрилі, представлені 14 (17,3%) видами у зовнішній зоні (650 км²) і вісьмома видами (23,5%) у внутрішній зоні. Копитні, хоча здебільшого рідкісні або незвичні, були представлені у зовнішній зоні вісьмома (9,9%) видами. У внутрішній зоні не було зареєстровано жодного виду. Дев'ятнадцять видів хижих ссавців (23,5%) були зареєстровані у зовнішній зоні, але лише два з них - у внутрішній. Інші види, зареєстровані у Віндгуку, були представниками семи інших рядів: Eulipotyphla (n = 4 види), Macroscelidea (n = 3 види), Lagomorpha (n = 3), Hyracoidea (n = 1), Примати (n = 2), Tubulidentata (n = 1) і Pholidota (n = 1). Два види, *Cynictis penicillata* і *Xerus inauris*, виявилися відносно поширеними у внутрішній зоні. Вони досягли вищої щільності популяції (5,6 та >2,0 особин на 100 га відповідно), ніж у будь-якому іншому місті Намібії, і, ймовірно, у південній Африці в цілому. Незважаючи на інтенсивні пошуки у внутрішній зоні, *Hystrix africaustralis* і *Procavia capensis* були зареєстровані лише на зарослому чагарниками пагорбі. Чисельність *Procavia capensis* оцінена в 40–70 особин. Нечисленні групи *Papio ursinus* мешкають лише у зовнішній зоні. Наступні види, зареєстровані у Віндгуку, занесено до Червоного списку видів, що перебувають під загрозою зникнення МСОП: *Acinonx jubatus*, *Panthera pardus*, *Felis nigripes*, *Manis temminckii* і *Hyena brunnea*. Важливо відзначити відсутність будь-яких чужорідних видів ссавців у внутрішній, і тільки *Mus musculus* є у зовнішній зоні міста. Охорона ссавців у Віндгуку, особливо у зовнішній зоні, може стати каталізатором, який спонукатиме муніципалітет до більш ефективного збереження біорізноманіття.

Ключові слова: міська екологія, урбаністичний градієнт, контрольний список видів, щільність населення, Віндгук.

Introduction

In sub-Saharan Africa, most cities were founded in the 19th century. However, due to their rapid development, in many African countries more people live today in cities than in rural areas. Whereas in 1950, c. 10% of African population lived in urban areas, the urban population is projected to reach about 55% by 2050, with at least nine megacities (>10 mln inhabitants each). This rapid urbanisation has caused fragmentation and/or destruction of natural habitats, environmental pollution, and biodiversity decline [Gunerlap *et al.* 2018]. For some animal species, urbanization brought, however, some benefits through a creation of new shelters, nesting and roosting sites, an increase of food resources, and, at the same time, decrease of competition and natural predation [e.g. Kopij 2023a–b].

Mammals are probably one of the most affected groups of animals in urbanised environment throughout the world. In Africa, forest-dwelling primates, carnivorans, and ungulates seem to be especially negatively affected by urban development [Zungu *et al.* 2019; Schnetler *et al.* 2021; Thatcher *et al.* 2021]. However, to date, thorough investigation of the entire mammalian assemblages has not been conducted in any African city (Table 1). Most studies were limited to single species causing problems to locals. These are usually carnivorans, less often primates and rodents.

In Africa, especially problematic in urbanised environment are small rodents. Studies on small mammal communities were therefore the main subject of mammal research in this environment. The studies aimed to determine the abundance, habitat selection or parasites of particular species com-

prising the communities (Table 1). To date, however, very few researchers have focused on the abundance of large and medium-sized mammal species occurring in cities. Such knowledge is, however, of a prime importance in detecting population trends and urbanisation mechanisms. Such knowledge may also enable to formulate rational wildlife management policies, conservation or control measures.

Likewise, in Windhoek, quantitative studies were conducted on assemblages of small terrestrial mammals for parasitic examination (Table 1), but neither the entire mammal assemblage nor any mammal species was a subject of thorough investigation so far. The purpose of this study was to evaluate the status and abundance of all mammal species in Windhoek and its surroundings.

Study area

The study was confined to the city of Windhoek, on the plateau of the Khomas Highland in central Namibia (Fig. 1). The city is situated at c. 1700 m a.s.l. The Windhoek area was settled in 1840, while in 1890 it was created the local headquarter of the colonial German Empire. The population grew by more than four times from 1981 to 2020: 96 057 in 1981, 325 858 in 2011, and 431 000 in 2020 (www.macrotrends.net).

Table 1. Mammals investigated in African cities

Таблиця 1. Ссавці, досліджені в африканських містах

Mammal species	City	Aspects investigated	Source
Mammals	Bloemfontein, SA	Diversity	[Kopij & Eksteen 1996]
Forest mammals	Durban, SA	Diversity	[Zungu <i>et al.</i> 2019]
Forest mammals	Durban, SA	Forest fragmentation effect	[Manqoba <i>et al.</i> 2020]
Macromammalia	Cape Town, SA	Diversity	[Schnelzer <i>et al.</i> 2021]
Micromammalia	Cotonou, Niamey; West Africa	Small mammal communities, invasive vs. indigenous	[Hima <i>et al.</i> 2019]
Micromammalia	Niamey, Niger	Small mammal community	[Garba <i>et al.</i> 2014]
Micromammalia	Windhoek, Namibia	Small mammal community, ecto- parasites	[Mfuni <i>et al.</i> 2013]
Micromammalia	Cotonou, Benin	Small mammal community	[Houemenou <i>et al.</i> 2014]
Micromammalia	Kibera, Kenya	Small mammal community	[Halliday <i>et al.</i> 2015]
Micromammalia	Accra, Ghana	Small mammal community, habitat selection	[Garshong <i>et al.</i> 2013, Gbogbo <i>et al.</i> 2017, Ofori <i>et al.</i> 2018]
Micromammalia	Franceville, Gabon	Small mammal community	[Mangombi-Pambou 2023]
Cape grysbok	Port Elizabeth	Diet	[Kigozi <i>et al.</i> 2008]
Leopard	Nairobi, Kenya	Human-wildlife conflict	[Landy <i>et al.</i> 2018]
Spotted hyaena	Harar, Tigray; Ethiopia	Foraging in rubbish dumps	[Abay <i>et al.</i> 2011; Yirga <i>et al.</i> 2015]
Caracal	Cape Town, SA	Human-wildlife conflict	[Natrass & O’Riain 2020]
South African large-spotted genet	Kloof, Hillcrest; SA	Home range, habitat use; human-wildlife conflict, diet	[Widdows 2015; Widdows & Downs 2015]
Water mongoose	Durban, SA	Home range, habitat use; diet	[Streicher <i>et al.</i> 2021, 2022]
Yellow mongoose	Windhoek, Namibia	Population size	This study
Chacma baboon	Cape Town, SA	Human-wildlife conflict	[Hoffman & O’Riain 2012; Bentley <i>et al.</i> 2015; Drewe <i>et al.</i> 2012]
Vervet monkey	Durban, SA	Home range, habitat selection, human-wildlife conflict	[Patterson <i>et al.</i> 2019; Thacher <i>et al.</i> 2021]
Rock hyrax	Bloemfontein, SA	Population size, control measures	[Wiid & Butler 2015]
Cape porcupine	Ballito, KZN, SA	Home range	[Ngcobo <i>et al.</i> 2019]
Cape ground squirrel	Windhoek, Namibia	Population size	This study

For the purpose of this study, two zones were distinguished: inner zone, c. 2–6 km around the centre, with a surface area of c. 50 km², and outer zone further afield up to 15 km around the centre (c. 650 km²). The inner zone is largely a built-up area (Fig. 2), while the outer zone is largely an un-built-up area, with some pastoral activities. The outer zone is a mountainous area covered with the Highland Shrubland, a kind of Acacia tree-and-shrub savanna [Mendesohn *et al.* 2009]. This natural vegetation is largely transformed or removed all together in the inner zone of the city and is replaced by exotic trees (mainly acacias, with some jacarandas, gums, cypresses, etc.), shrubs and herbs (often dense and luxuriant on private properties) [Kopij 2023a–b]. There are remnants of natural vegetation along watercourses (i.e. the Arebbusch with Gammams, and Kleinwindhoek Rivers, and their tributaries) and on higher and steeper hills (e.g. Aloe Trail, Botanic Garden in the inner zone).

Windhoek with a hot semi-arid climate is located in resource-poor areas and experience recurrent severe shortages of water. The annual average temperature is above 18°C. The temperature throughout the year would be called mild, due to altitude influence. Precipitation is high in the summer season and minimal during the winter season. The average annual precipitation is 367.4 mm.

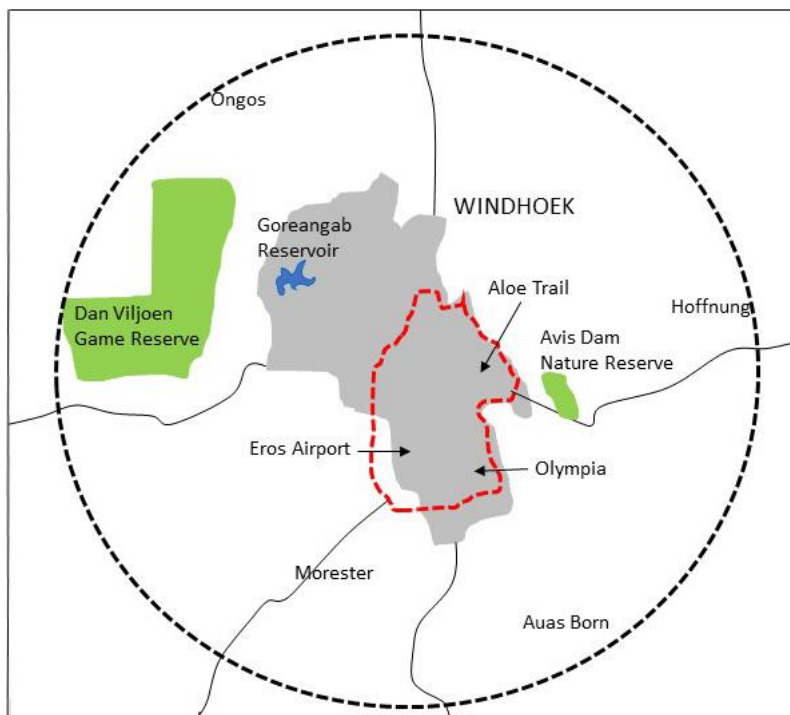


Fig. 1. The outer (black circle, 15 km around the centre, 650 km²) and the inner (red line, 50 km²) zones of Windhoek.

Рис. 1. Зовнішня (обведена чорним кольором, 15 км навколо центру, 650 км²) та внутрішня (визначена червоною лінією, 50 км²) зони Віндгука.

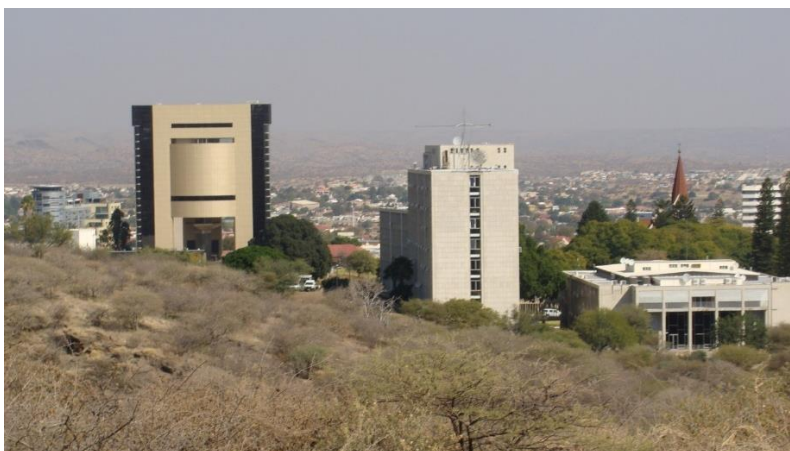


Fig. 2. Windhoek downtown viewed from the Aloe Trail in the inner zone.

Рис. 2. Центр міста Віндгук, вид на нього зі Стежки алоє у внутрішній зоні.

Material and Methods

Data on the occurrence of species in Windhoek were collected during the years 2011–2020. Whenever mammals were spotted/caught, an attempt was made to identify them to species level either directly in the field or from the photographs; habitat was described and site was located on a map. In this study excluded are records of mammals introduced, translocated, or kept in enclosures (e.g. in Dan Viljoen Game Park). Studies were much more intense in the inner (much smaller area, but much higher human population) than in the outer zone (much larger area, but much lower human population) of the city. Within the inner zone, studies were more intense in the western than in the eastern part. Studies on the distribution, numbers, and habitat selection of selected mammal species (yellow mongoose, Cape porcupine, rock dassie, and Cape ground squirrel) were conducted in the inner zone of Windhoek in August 2020. The entire study area was carefully surveyed along streets. Special attention was paid to shrubby hills, river valleys, and patches of natural vegetation. In the course of survey, all occupied dens and warrens were mapped. Only dens/warrens where also animals were observed were regarded as occupied. An attempt was also made to estimate the number of animals present in such sites. Around each site habitat was described.

Studies on small mammals were conducted in two sites: Eros airport [by Hauptfleisch & Avenant 2015] and Olympia and surroundings [by Mfuno *et al.* 2013]. At the Eros airport, a 495 m long transect was designed with 100 traps spaced by 5 m. Traps were baited for four consecutive nights, twice a year (dry and wet season), in 2011 and 2012. Traps were checked twice a day. In Olympia and surroundings, 50 traps were spaced 10 m apart. Traps were set for four consecutive nights in 2005, and checked once a day. The following scale was used to estimate population size of particular species: status uncertain (visitor or rare): +, Rare: 1–10; Uncommon: 11–100; Common: 101–1000; Abundant: >1000 territories/family groups/breeding sites per 100 km².

The systematics and nomenclature used follow Wilson & Mittermeier [2009–2019]. Scientific names of mammal species are given in Table 2. Scientific names of all other species not included in Table 1, are given in a traditional way, i.e. when the species is mentioned in text for the first time.

Results

During the years 2011–2020, 81 mammal species were recorded in Windhoek. All species were recorded in the outer zone, but only 34 (42.0%) species in inner zone (Table 2). Rodents (Rodentia) formed the most speciose order in both zones (25 species; 30.9%). The group was, however, proportionally more speciose in the inner (50.0% of all mammal species) than in the outer zone (30.9%). The second most speciose group of mammals were bats (Chiroptera) represented by 14 (17.3%) species in the outer zone and eight species (23.5%) in the inner zone. Ungulates, although mostly rare or uncommon, were in the outer zone represented by eight (9.9%) species. None was, however, recorded in the inner zone. Similarly, nineteen species (23.5%) of carnivores were recorded in the outer zone, but only two of them in the inner zone. Other species recorded in Windhoek were representatives of seven other orders: insectivores Eulipotyphla (n = 4 species), elephant shrews Macroscelidea (n = 3), lagomorphs Lagomorpha (n=3), hyraxes Hyracoidea (n = 1), primates Primates (n = 2), aardvarks Tubulidentata (n = 1), and pangolins Pholidota (n = 1) (see: Table 2).

Within the order Rodentia, the most speciose was the family Muridae (n = 13 species), while the most common species within the order were *Rhabdomys pumilio*, *Mastomys coucha*, *Gerbilliscus leucogaster*, and *Gerbillurus paeba*. While the two former (from the subfamily Murinae) appear to prefer grassy places, the two later species (from the subfamily Gerbillinae) show higher preference to shrubby habitats (Table 3). Except for the Cape ground squirrel, other rodent species were rarely encountered. Their status in Windhoek is not clear and requires further investigation.

Bats recorded in Windhoek belong to five families. The vesper bats (Vespertilionidae) were represented by six species, the horseshoe bats (Rhinolophidae) by five species, while only a single species represented the remaining families (see: Table 2). Knowledge on their distribution, numbers, and habitat selection in the city is obscure and requires further investigations.

Table 2. Status of mammalian species in the outer and inner zones of Windhoek in 2011–2020. Sign '+' denotes a recorded species with uncertain status, while the sign '-' denotes that the species was not recorded

Таблиця 2. Статус видів ссавців у зовнішній та внутрішній зоні Віндгука у 2011–2020 роках. Знак "+" означає, що вид був зареєстрований, але непевно; знак "-" означає, що вид не зареєстрований

Order and family	Species	Outer zone 650 km ²	Inner zone 50 km ²
CHIROPTERA			
Molossidae	Egyptian free-tailed bat <i>Tadarida aegyptiaca</i>	common	common
Vespertilionidae	Long-tailed greater serotine bat <i>Eptesicus hottentotus</i>	+	-
	Angola wing-gland bat <i>Myotis seabrai</i>	+	-
	Schreiber's long-fingered bat <i>Miniopterus natalensis</i>	+	+
	Cape serotine bat <i>Eptesicus capensis</i>	+	+
	African yellow bat <i>Scotophilus dinganii</i>	+	+
Eastern greenish yellow bat <i>Scotophilus viridis</i>		+	+
Nycteridae	Common slit-faced bat <i>Nycteris thebaica</i>	common	+
Rhinolophidae	Darling's horseshoe bat <i>Rhinolophus darlingi</i>	+	+
	Rüppell's horseshoe bat <i>Rhinolophus fumigatus</i>	+	-
	Geoffroy's horseshoe bat <i>Rhinolophus clivosus</i>	+	-
	Dent's horseshoe bat <i>Rhinolophus denti</i>	+	-
	Commerson's horseshoe bat <i>Rhinolophus commersoni</i>	+	-
Hipposideridae	Sundevall's leaf-nosed bat <i>Hipposideros caffer</i>	common	+
EULIPOTYPHLA			
Soricidae	Lesser red musk shrew <i>Crocidura hirta</i>	+	+
	Bicoloured musk shrew <i>Crocidura fuscomurina</i>	+	-
	Reddish-grey musk shrew <i>Crocidura cyenea</i>	+	-
Erinaceidae	South African hedgehog <i>Atelerix frontalis</i>	rare	-
MACROSCELIDEA			
Macroscelididae	Round-eared elephant shrew <i>Macroscelides proboscideus</i>	+	-
	Bushveld elephant shrew <i>Elephantulus intufi</i>	uncommon	uncommon
	Smith's rock elephant shrew <i>Elephantulus rupestris</i>	+	-
RODENTIA			
Muridae (Murinae)	Four-striped grass mouse <i>Rhabdomys pumilio</i>	abundant	abundant
	House mouse <i>Mus musculus</i>	rare	+
	Desert pygmy mouse <i>Mus indutus</i>	uncommon	uncommon
	Southern multimammate mouse <i>Mastomys coucha</i>	abundant	abundant
	Natal multimammate mouse <i>Mastomys natalensis</i>	+	-
	Acacia tree mouse <i>Thallomys paedulus</i>	+	+
	Black-tailed tree rat <i>Thallomys nigricauda</i>	uncommon	uncommon
	Namaqua rock mouse <i>Aethomys namaquensis</i>	+	-
	Red veld rat <i>Aethomys chrysophilus</i>	+	+
	Muridae (Gerbillinae)	Cape short-tailed gerbil <i>Desmodillus auricularis</i>	uncommon
Bushveld gerbil <i>Gerbilliscus leucogaster</i>		common	common
Highveld gerbil <i>Gerbilliscus brandsi</i>		+	-
Pygmy hairy-footed gerbil <i>Gerbillurus paeba</i>		common	common
Nesomyidae (Cricetomyiinae)	Pouched mouse <i>Saccostomus campestris</i>	+	uncommon
Nesomyidae (Dendromurinae)	Large-eared mouse <i>Malacothrix typica</i>	+	-
	Fat mouse <i>Steatomys pratensis</i>	+	+
	Pygmy rock mouse <i>Petromyscus collinus</i>	+	+
Petromuridae	Dassie rat <i>Petromus typicus</i>	rare	-
Gliridae	Woodland dormouse <i>Graphiurus rupicola</i>	+	rare
	Rock dormouse <i>Graphiurus platyops</i>	+	-

Order and family	Species	Outer zone 650 km ²	Inner zone 50 km ²
Sciuridae	Cape ground squirrel <i>Geosciurus inauris</i>	common	common
	Koakoveld ground squirrel <i>Geosciurus princeps</i>	+	-
Bathyergidae	Damara mole-rat <i>Cryptomys damarensis</i>	+	+
Hystricidae	Cape porcupine <i>Hystrix africaustralis</i>	common	uncommon
Pedetidae	Cape spring hare <i>Pedetes capensis</i>	+	-
LAGOMORPHA			
Leporidae	Jameson's red rock rabbit <i>Pronolagus randensis</i>	+	rare
	Cape hare <i>Lepus capensis</i>	common	uncommon
	Scrub hare <i>Lepus saxatilis</i>	common	-
HYRACOIDEA			
Hyracoidea	Rock dassie <i>Procavia capensis</i>	common	common
ARTIODACTYLA			
Suidae	Warthog <i>Phacochoerus africanus</i>	+	-
Bovidae	Red hartebeest <i>Alcephalus buselaphus</i>	+	-
	Common duiker <i>Sylvicapra gimmia</i>	+	-
	Springbok <i>Antidorcas marsupialis</i>	+	-
	Klipspringer <i>Oreotragus oreotragus</i>	+	-
	Steenbok <i>Raphicerus campestris</i>	common	-
	Gemsbok <i>Oryx gazella</i>	+	-
Kudu <i>Tragelaphus strepsiceros</i>	common	-	
CARNIVORA			
Hyaenidae	Aardwolf <i>Proteles cristatus</i>	rare	-
	Spotted hyaena <i>Crocuta crocuta</i>	rare	-
	Brown hyaena <i>Hyaena brunnea</i>	rare	-
Felidae	Cheetah <i>Acinonyx jubatus</i>	rare	-
	Leopard <i>Panthera pardus</i>	rare	-
	Caracal <i>Felis caracal</i>	uncommon	-
	African wild cat <i>Felis lybica</i>	uncommon	-
	Small spotted cat <i>Felis nigripes</i>	rare	-
Canidae	Bat-eared fox <i>Otocyon megalotis</i>	rare	-
	Cape fox <i>Vulpes chama</i>	uncommon	-
	Black-backed jackal <i>Canis mesomelas</i>	common	-
Mustelidae	Honey badger <i>Mellivora capensis</i>	uncommon	-
	Striped polecat <i>Ictonyx striatus</i>	uncommon	-
Viverridae	Small-spotted genet <i>Genetta genetta</i>	+	-
Hesperidae	Yellow mongoose <i>Cynictis penicillata</i>	common	common
	Slender mongoose <i>Galerella sanguinea</i>	common	uncommon
	Small grey mongoose <i>Galerella pulverulenta</i>	+	-
	Suricate <i>Suricatta suricatta</i>	uncommon	-
Banded mongoose <i>Mungos mungo</i>	+	-	
PRIMATES			
Lorisidae	Southern lesser galago <i>Galago moholi</i>	rare	-
Cercopithecidae	Chacma baboon <i>Papio ursinus</i>	common	uncommon
TUBULIDENTATA			
Oryctopodidae	Aardvark <i>Orycteropus afer</i>	+	-
PHOLIDOTA			
Manidae	Ground pangolin <i>Smutsia temminckii</i>	+	-

Table 3. Small mammal assemblages in the inner zone of Windhoek

Таблиця 3. Угрупування дрібних ссавців у внутрішній зоні Віндгука

Order and family	Species	Olympia, habitat: shrubland (2005)		Eros Airport, habitat: grassland (2011–2012)	
		N	%	N	%
Rodentia					
Muridae					
Murinae	<i>Rhabdomys pumilio</i>	1	1.6	278	47.4
	<i>Mus indutus</i>	0	0.0	56	9.6
	<i>Mastomys coucha</i>	0	0.0	201	34.3
	<i>Thallomys nigricauda</i>	2	3.3	0	0.0
	<i>Thallomys paeduleus</i>	0	0.0	1	0.2
Gerbillinae	<i>Desmodilus auricularis</i>	0	0.0	1	0.2
	<i>Grebilliscus leucogaster</i>	29	47.5	22	3.8
	<i>Gerbillurus paeba</i>	18	29.5	0	0.0
Nesomyidae	<i>Saccostomys campestris</i>	0	0.0	3	0.5
Macroscelidea					
Macroscelididae	<i>Elephantulus intufi</i>	11	18.0	24	4.1
Total number of individuals caught		61		564	
Source		[Mfuni <i>et al.</i> 2015]		[Hauptfleisch & Avenant 2015]	

Except for the yellow mongoose, smaller carnivorans are rare and/or unrecorded in Windhoek. Also little is known about insectivorous mammals in the city.

Two species, the yellow mongoose and Cape ground squirrel were found to be relatively common in the inner zone of Windhoek (Fig. 3, 4). They have reached a population density higher than in any other cities in Namibia, and probably in southern Africa at large (own observ.). In total, 29 warrens of the Cape ground squirrel were found, with most located on the railway sides, Eros airport, and in the north-eastern part of the inner zone (Fig. 3). In nine warrens, the number of animals was counted. The number ranged from 3 to 20, with an average of 9.8 (SD = 7.1; Var.: 49.7). Based on this, the entire population in the inner zone of Windhoek (51 km²) can be estimated at 284 individuals or 5.6 per 100 ha.

The yellow mongoose were the most common in the north-western part of the town, especially around the Aloe Trail hill. In total, 20 territories were located (Fig. 4), and the number still may be underestimated. Individuals may have a home range of up to 100 ha; warrens are inhabited usually by 2–3 adults and their young; litter size (emerging from burrows): 1–2, with 2–3 litter per year, in average 5–6 individuals per warren [Kingdon 1997; Hunter 2011]. Based on these data, the estimated number of the yellow mongoose in the inner zone is more than 100 individuals or >2 individuals per 100 ha. Like Cape ground squirrels, they avoid this part of the inner zone of Windhoek, which lays south of the main east-west railway, devoid of larger water courses and unbuilt shrubby hills.

Despite intense searching in the inner zone, the Cape porcupine was only recorded in the Aloe Trail hill, and specifically only in the Botanic Garden located in the north-eastern part of the hill (Fig. 5), where it is safe from human persecution [Kopij 2022]. Similarly, the rock dassie occurs only in this hill. It is, however, quite widespread all over this place. They live there in small groups established in rocky crevices. The population was estimated at 40–70 individuals, with about half in the Botanic Garden. Troops of the chacma baboon were often recorded in the inner zone of Windhoek, but only in the outskirts (Eros, Klein Windhoek, Avis, and Kleine Kuppe; Fig. 5). A few troops are resident in the outer zone. Their exact numbers, however, are unknown.

The following species recorded in Windhoek are in the IUCN Red List of Threatened Species [IUCN 2023]: cheetah (VU), small spotted cat (VU), Cape pangolin (VU), leopard (VU), and brown hyaena (NT). Noteworthy is the absence of any alien mammal species in Windhoek, except for the house mouse.

Among the 32 mammal species that occurred both in the outer and inner zones, 12 had the same status. Only 2 species were recorded as abundant in both zones; 16 common species were recorded in the outer zone, while 6 common species in the inner zone; 20 species were uncommon and rare in the outer zone, while 11 such species were recorded in the inner zone.

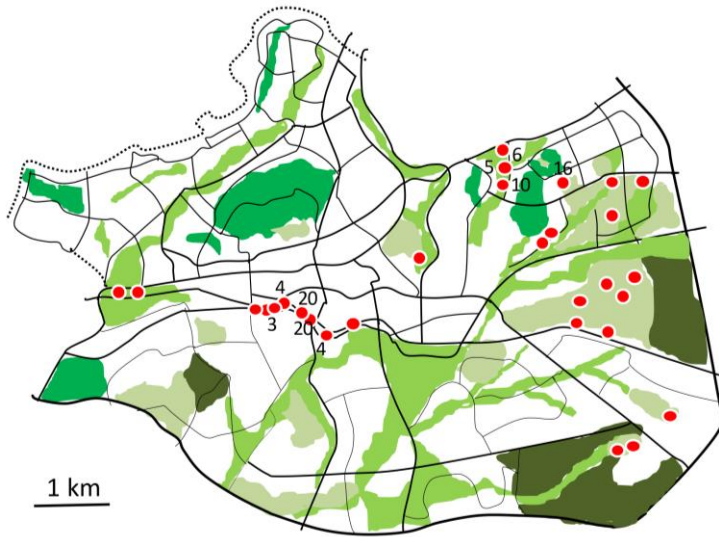


Fig. 3. Cape ground squirrel colonies in the inner zone of Windhoek in 2020. Number of individuals is given for some colonies.

Рис. 3. Колонії ховрахів у внутрішній зоні Віндгука у 2020 році. Кількість особин вказана для деяких колоній.

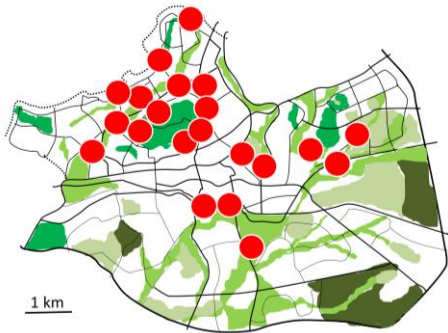


Fig. 4. Yellow mongoose territories/colonies in the inner zone of Windhoek in 2020.

Рис. 4. Території/колонії мангуста жовтого у внутрішній зоні Віндгука у 2020 році.

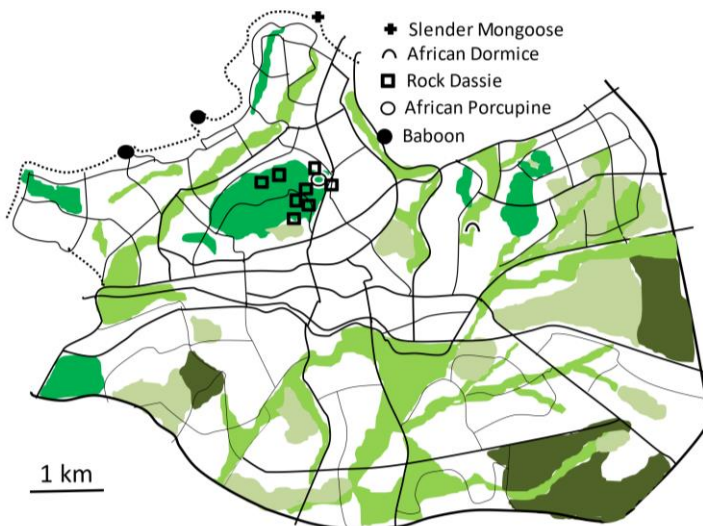


Fig. 5. Territories of some mammal species in the inner zone of Windhoek in 2020.

Рис. 5. Території деяких видів ссавців у внутрішній зоні Віндгука у 2020 році.

Discussion

In terms of species diversity, the inner zones of cities in southern Africa are dominated by small mammals. As shown in Windhoek and Bloemfontein, they comprise more than half of the total number of common species recorded (Table 4). On the other hand, ungulates are usually absent altogether in the inner zone, but they are quite common in the outer zone. Maun and Kasane in Botswana are exceptions in this regard, as the warthog (*Phacochoerus africanus*) is a common species, even in the centres of these towns. It forages mainly on food remains left by people. In Namibia, they clearly avoid all towns, and even in areas where the population reaches high density, they are absent in towns and their surroundings. For example they are absent in such towns as Tsumeb, Otjivarongo, and Okahanja, and even in areas 20–30 km around these towns. They are, however, abundant in the neighbouring bushes. In Namibia, it is probably persecuted by people with dogs, and it avoids any larger human settlements where it is disturbed, harassed, and killed. Kasane and Maun are located close to larger protected areas, where warthogs thrive, undisturbed by human activities. However, even in these towns they are generally not harassed by people, although sows with piglets, are probably vulnerable to dogs, as they were never seen in these towns (own observ.).

No alien species were hitherto reported from the inner zone of Windhoek, and only the house mouse (*Mus musculus*) was recorded in the outer zone. The brown rat (*Rattus norvegicus*) and house mouse are widespread and often common in many southern African towns, especially those situated by the ocean. The black rat (*Rattus rattus*) was also reported in Swakopmund and Walvis Bay on the Namibian Atlantic coast (own observ.).

Squirrels are often a characteristic faunistic element of cities all around the world. In many cities they were introduced, in others they were resident from the beginning. In southern Africa, however, squirrels are not as common in cities as it could be expected. In Namibia, tree squirrels (*Paraxerus cepapi*) occur commonly in Katima Mulilo only (own observ.), while ground squirrels were recorded in larger numbers in Windhoek only. In Cape Town, the introduced alien eastern grey squirrel (*Sciurus carolinensis*) is common everywhere [Cilliers & Siebert 2012]. The occurrence of the Cape ground squirrel in sustainable numbers in Windhoek is therefore somehow a unique feature of the southern African urban wildlife.

Mongoose are another mammalian group characteristic for African cities. Their European equivalents include mustelids, such as martens, polecats, or badgers. In southern Africa, the slender and yellow mongoose are the most often encountered species, a situation seen also in Windhoek. In more humid and wooded regions, genets (small-spotted and South African large-spotted *Genetta tigrina*) also occur. The former one was also recorded in Windhoek.

Table 4. Mammal species recorded as common or abundant in the inner zone of Windhoek (50 km²) (this study) and in the inner zone of Bloemfontein (50 km²) [Kopij & Eksteen 1996]

Таблиця 4. Види ссавців, зареєстровані як звичайні або численні у внутрішній частині Віндгука (50 км²) (це дослідження) та внутрішній зоні Блумфонтейну (50 км²) [Копій & Екстейн 1996]

Species	Windhoek	Bloemfontein
Egyptian free-tailed bat <i>Tadarida aegyptiaca</i>	common	common
Cape serotine bat <i>Eptesicus capensis</i>	?	common
Vlei rat <i>Otomys irroratus</i>	–	common
Four-striped grass mouse <i>Rhabdomys pumilio</i>	abundant	abundant
House mouse <i>Mus musculus</i>	rare	common
Multimammate mouse <i>Mastomys coucha</i>	abundant	common
Bushveld gerbil <i>Gerbilliscus leucogaster</i>	common	–
Pygmy hairy-footed gerbil <i>Gerbillurus paeba</i>	common	–
Cape ground squirrel <i>Geosciurus inauris</i>	common	–
Common mole-rat <i>Cryptomys hottentotus</i>	–	abundant
Cape hare <i>Lepus capensis</i>	uncommon	common
Rock dassie <i>Procavia capensis</i>	common	common
Yellow mongoose <i>Cynictis penicillata</i>	common	rare

In southern Africa, some mammal species may cause human-wildlife conflicts. Two primate species, namely the chacma baboon and blue monkey (*Cercopithecus mitis*) may become common in some cities. They were reported as pests of cultivated plants in cities such as Cape Town, Durban, and Katima Mulilo (own observ.). In Windhoek, chacma baboons cause some problems in the peripheral suburbs (Eros, Klein Windhoek, Avis, and Kleine Kuppe), while in Katima Mulilo, both the chacma baboon and blue monkey are known as pests of maize and other cultivated plants on the peripheries of the town (own observ.).

However, in Windhoek, most mammal species do not pose any human-wildlife conflicts. Their protection, especially in the outer zone, may act as a catalyst to move the municipality governance towards a more effective biodiversity conservation, which, in turn, can offer to its human population a better quality of life, more recreational activities, a legacy of natural history, and a source of national pride.

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