

Review

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Review

Alien Mammals in the Afrotropical Region and Their Impact on the Vertebrate Biodiversity: A Review

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Abstract: Introduction of alien species may pose enormous threat to indigenous flora and fauna. Among introduced animals probably the most destructive to the natural environment are mammals. This is true at least in regard to the Afrotropical Region (sub-Saharan Africa). The presented paper attempt to summarize our knowledge on alien mammals in this region and their impact on the indigenous vertebrate fauna. This review includes 56 mammal species belonging to 20 families introduced to sub-Saharan Africa in the last 2000 years. Most are representatives of the following orders: Artiodactyla Carnivora and Primates. Most species introduced to sub-Saharan Africa originated from the Oriental (n = 20) and Palearctic Region (n = 19). Two species, *Mus musculus* and *Rattus rattus*, have been introduced before 1400 (probably as early as 800 AD); three other were introduced between 1401 and 1700. The first half of the 17th century saw the highest number (n = 10) of introduced species. While during the years 1651 and 1850, only two species were introduced, in the following 175 years (1851-2025) as many as 24 species were introduced. Ten of the introduced mammal species, namely *Sus scrofa*, *Capra hircus*, *Rattus rattus*, *R. norvegicus*, *Mus musculus*, *Felis catus*, *Canis familiaris*, *Viverricula indica*, *Uroa auropunctata* and *Maccaca fuscicularis* become invasive species. A total of 39 mammal species were relocated (mainly for hunting purpose) within sub-Saharan Africa. Most of them were representatives of the family Bovidae (76.9%). Relocations are not considered as introductions. Based on published records of impacts of alien mammals on the vertebrate fauna of the sub-Saharan Africa, the following mechanisms may be distinguished: predation, competition, hybridization, transmission of diseases and parasites; habitat destruction (grazing / herbivory / browsing). Most vertebrate species (79.4%) were affected through direct predation or predation and habitat destruction (7.1%) or predation and competition (1.4%). Alien mammals has caused habitat destruction for only 10 species (7.1%). Other effects (competition and genetic pollution) were marginal (3.5%). At least 144 vertebrate species represented by 52 families were affected by alien mammals in sub-Saharan Africa, 3 amphibian, 23 reptiles, 89 birds and 29 mammals. As result of mammal introduction, 65 species in sub-Saharan Africa became globally extinct, 45 are threatened (in RDB) and 31 other species are in decline, although not included in RDB. Most extinct birds were affected by introduced rats, mouse feral cats and dogs. In continental Africa, only seven vertebrate species are negatively affected by alien mammals. All the others affected vertebrates occur on islands. Especially high rate of extinction was recorded in the Mascarenes. In comparison with alien birds in sub-Saharan Africa, the number introduced mammals species is much lower, but their negative effect on vertebrate fauna much higher.

Keywords: introduction; invasive species; distribution; extinction; biodiversity conservation

1. Introduction

Sub-Saharan Africa harbors the richest and most diverse mammal fauna in the world, especially in regard to larger mammals (ungulates, carnivores, primates). For long time the fauna was also best preserved. While in other regions of the world, most members of the mammal megafauna were decimated and went into extinction, in Africa most of them survived. The conservation status has

however changed since the European penetration of this continent started in the 15th century by Portugal and latter also by the Netherlands, France, Belgium and Great Britain. For the first four centuries of European presence in sub-Saharan Africa, the African interior remained however almost untouched. The coast and small islands around the continent were however affected. However, even earlier, beginning with the 1st century AD, the fauna of the biggest African island, Madagascar, was negatively affected by Malayan-Polynesian (Austronesian) colonizers, who were in 9th century joined by Bantu people from East Africa (Michell 2022).

The European contacts with sub-Saharan Africa begun with the Portuguese penetration of the world at the beginning of the 15th century. Most of the small oceanic islands have systematically occupied by man and his domestic animals. The changes greatly accelerated both on the coast, islands and in the interior at the end of 19th century, mainly due to French and British colonizers of Africa. The 20th century saw dramatic devastations of the natural environment. Many animal species, especially the larger mammals, became threatened, to such an extent that a need for special protection in reserves and national parks arose. Fortunately, in many countries (e.g. South Africa Namibia, Botswana, Zimbabwe, Zambia, Tanzania, Kenya, Uganda), networks of extensive protected areas were established, often with more than 10% of a country surface area covered with national parks and reserves (Groom et al. 2006; King 2010).

Man negatively affected the nature in sub-Saharan Africa mainly through excessive hunting (mostly on vertebrates) and habitat destruction and pollutions. However, in the last centuries, beside the habitat destruction, alien species, directly or indirectly introduced by man, became one of the biggest threat to the fauna, not only in Africa, but throughout the world (Groom et al. 2006). This process become especially acute in the end of 20th and beginning of 21st century, with the increase of commers and tourism. In many regions of the world affords were undertaken to investigate and mitigate this negative process. In Africa, these affords concentrated in South Africa and some islands surrounding Africa, e.g. Cape Verde, São Tomé, Mauritius, Seychelles, Marion (King 2010).

Among the alien species, especially important appear to be mammals. Some species have been domesticated and brought to Africa as farm animals, some others have been introduced as highly valued game animals and other, like rodents, were introduced accidentally. In many regions of sub-Saharan Africa they become destructive to local biodiversity, especially to the vertebrate fauna. Reviews of such species and their impacts on the local fauna were subject of some regional reviews, e.g. South Africa (Bigalke & Pepler 1991; Measey et al. 2020) or western Indian Oceanic islands (Russel et al. 2016), but both the introduced mammal species and their impact on the vertebrate fauna in the whole sub-Saharan Africa have not been comprehensively reviewed to date. Such review are available for Europe (Genovesi et al. 2009), South America (Ballari et al. 2016; Rodriguez 2001) and Australia (Tooms et al. 2019). In this article, an attempt is undertaken to present a similar review for sub-Saharan Africa. It is done not only to facilitate intercontinental comparison, but to encourage researchers to further investigate this urgent conservation issue, so that it can be sufficiently controlled and mitigated and resolved.

2. Material and Methods

The review includes all mammal species ever introduced to Africa and its islands in the last 2000 years (since Madagascar was colonized by Austronesian people). The time is especially important in the case of islands, which were not occupied by man in earlier time. Species accounts are provided for those that have formed self-sustaining populations, including all stages up to full invasions.

Literature on mammalian introduction in Africa south of Sahara, was reviewed since 1950 onwards. All islands around this continent were also included, i.e. Cape Verde; São Tome e Principe, Bioko and Annobón of the Equatorial Guinea; Madagascar; small oceanic islands around Madagascar, i.e.: Mascarenes (Mauritius, Reunion, Rodrigues and other), Seychelles, Comoros; Mafia, Zanzibar, Pemba off Tanzania; Socotra in the Gulf of Aden; and two subantarctic islands: Marion and Prince Edward.

For searching relevant literature the Google Scholar bibliographic database (scholar.google.com) was used. The following key words were used: introduced mammals (or alien mammals) + Africa (or particular African country and island). As key words also particular mammal species (both common and scientific names) were used + Africa (or particular African country and island), e.g. *Cervus dama* + Africa, Fallow Deer + Zimbabwe, etc. For the impact of alien mammal on vertebrate fauna the following key words were used: extinct (or threatened or endangered) + mammal (or bird or reptile, or amphibian, or fish) + Africa (or particular African country or particular African island). Special web-sites dealing with introduced mammal species were also consulted through direct searching in internet.

Definitions related to introduction and invasive species follow those in Kopij (2025). Nomenclature and systematics of mammals follow Llobet et al. 2023, birds – Clements et al. 2018, reptiles – Midtgaard 2025, amphibians – ANMH 2025. The conservation status of each species was assessed according to IUCN Red List of Threatened Species.

3. The Introduced Species

3.1. Feral/Domestic Species

Prior to the arrival of Arabs and Europeans, sub-Saharan Africa was inhabited by peoples already using domestic animals, such as Sheep *Ovis aries*, Goats, *Capra hircus*, Cattle, *Bos taurus* and Dogs *Canis familiaris* that were all alien to the region. Many of these domestic animals became feral causing serious environmental problems. The feral Goats, Donkeys *Equus asinus*, Pigs and Cattle cause massive impacts through competition with native species for food, altering the structure and composition of plant communities by grazing and rooting (e.g. Kurdila 1998; Campbell and Donlan 2005). This has led to habitat loss, resulting in local extinction of some native species and accelerated soil erosion. Other feral species, such as dogs and cats *Felis catus* caused huge impacts on fauna through predation, causing extinctions of numerous animals, especially common in islands. In many of these islands, and in some places on the continent, the problem continues.

3.1.1. Feral Cat *Felis Catus*

It occurs worldwide, including many small oceanic islands. Together with the rat, it is the most invasive and destructive mammal species in the world. It often occurs in large numbers in urbanized landscapes. For example population densities of cats in Cape Town, South Africa, have been estimated as 80–300 exx./km². In an urban conservancy in KwaZulu-Natal, South Africa, the density of cats was found to be between 23 and 40 exx./km² (Tennent and Downs 2008).

Feral cat can cause major impacts through predation leading to population declines, and in some cases local extirpation, of native mammals, reptiles, and birds (Fitzgerald and Veitch 1985; Winter and Wallace 2006; Bonnington et al. 2013). In small oceanic islands they contributed to the global extinction of some endemic species. It is also known to hybridize with the African Wild Cat *Felis sylvestris lybica* (Le Roux et al. 2005). It is regarded as one of the 100 worst invasive species in the world (ICNC 2025).

In 1949, five cats were introduced to a subantarctic Marion Island, South Africa, to help in eradicating mouse (introduced to the island earlier). However, the cat also preyed on seabirds, especially burrowing petrels (Procellariidae), decreasing their breeding success, and in consequence population declines (Bester et al. 2002). The cats soon went out of control, and begun to reproduce in a fast rate, so that by the year 1975 the population was so high that the cat became very destructive to marine birds breeding on the island. It was estimated that each year the cats were able to eliminate c. 450,000 petrels. Eradication scheme was implemented there in the 1980's and by the end of that decade the cat has been eliminated from the island (Bester et al. 2002; Davies et al. 2020).

3.1.2. Feral Dog *Canis familiaris*

The domestication of dog began at least 14,000 BP and from there began an ever increasing problem of feral dogs which threaten the biodiversity (Doherty et al. 2017; Hughes & Macdonald 2013). Domestic dogs encompass feral and free-ranging animals to those owned and completely dependent on humans; all can interact with wildlife (Doherty et al. 2017). The dog population has expanded around the globe alongside the human population and, in 1993, the most recent global population estimate was made at 500 million dogs (Wandeler et al., 1993). Free-roaming dogs, those that are not permanently restrained or under human control may account for about 75% of the global dog population. In Africa, there are today about 100 million dogs (Knobell et al. 2005).

Feral dogs come from domestic dogs which escaped or were abandoned or born to feral animals. As a result, today, in smaller or larger numbers, they are present in each corners of the world. In most African islands they were present since European colonization started, e.g. in São Tomé since 16th century; Madagascar about c. 1000 BP. (Doherty et al. 2017; Merz et al. 2021).

Dogs can affect other vertebrates species by spreading serious diseases and parasites. They are considered as the main carriers/reservoirs of rabies. Species affected include lions *Panthera leo*, side-striped jackals *Canis adustus*, black-backed jackals *Canis mesomelas*, bat-eared foxes *Otocyon megalotis*, Ethiopian wolves *Canis simensis*, African wild dogs *Lycaon pictus*, spotted hyenas *Crocuta crocuta*, white-tailed mongoose *Ichneumia albicauda* and honey badgers *Mellivora capensis*. The dog may also transmit the Canine Distemper Virus (CDV), leishmaniasis and one on hydatid disease caused by the transmission of *Echinococcus granulosus* (Macpherson et al., 1983). However, 79% of dog impact on biodiversity is through predation (Doherty et al. 2017).

Doherty et al. (2017) listed 200 vertebrate species (96 mammal spp., 78 avian spp., 22 reptile and 3 amphibian) which populations suffer from feral dogs, with 11 EX, 30 CR, 71 EN and 87 VU. Especially bad was the impact of feral dogs on giant lemurs in Madagascar, after their introduction to the island about 1000 years ago. They have greatly contributed to the global extinctions of most of them. Today, in sub-Saharan Africa 10-16 vertebrate species are affected by dogs (Doherty et al. 2017).

3.1.3. Feral Donkey *Equus asinus*

The feral donkeys are present in the following countries: South Africa, Namibia, São Tomé e Príncipe and Socotra (Blench 2004). Aerial counts around Steinkopf and Leliefontein estimate that there are as many as 274 donkeys in this area (Muller and Bourne 2018).

In Namibia they occur mainly in the Orange River valley in the extreme south in 1837 and in the Cuvelai Drainage System in Ovamboland in the central-north, where they were brought in 1851 (Mwenya & Keib 2004). In 2000, there were about 100,000 donkeys in Ovamboland, with many them being actually feral. During prolonged drought they are destructive to vegetation and by overgrazing they may promote invasive plant species as for example the bitter bush *Pechuel-Loeschea leubuitziae* (Asteraceae) and bush encroachment (G. Kopp, own observ.).

The greatest threat the donkey pose is hybridization with other species of the family Equidae, especially with the endangered Cape Mountain Zebra *Equus zebra zebra* (Brooke et al. 1986), producing so called 'zonkey'. Around Paulshoek in the Karoo, South Africa, residents complained that donkeys were destructive towards vegetation (Hoffman et al. 1999).

3.1.4. Feral Horse *Equus ferus caballus*

There are three known wild horse populations in South Africa, Namibia and Ethiopia. In South Africa, the largest is a population of at least 200 occupying an area of about 170 km² around Kaapsehoop in Mpumalanga province; and a population of more than 100 feral horses in the Steinkopf area of the Northern Cape province (Muller and Bourne 2018).

In Namibia, feral horses occur in the Gaub Plains of the Namib Desert near Aus, Karas Region, southern Namibia. Today the area is included to the Namib-Naukluft National Park. In 1964-1984, the number of animals varied between 50 and 200 (in most years 140-160); in 1984 an aerial survey

168 animals were recrded. In the course of ground survey carried out in 1988 the population was estimated at 150-200. Between 1993 and 2005, the population numbered between 89 and 149 animals (Greyling 2005). The most likely ancestors of the horses are a mix of riding horses and cavalry horses from German, released from various farms and camps in the early 20th century, especially during World War I. Despite the fact that the horses are alien to this region, they are not removed from the park, due to their historical attest and tourist attraction. The endangered Hartmann's Mountain Zebras *Equus zebra hartmannae* also occur in Namib-Naukluft Park, but their range do not overlap with that of the feral horses, and hybridization between the two species has not been recorded (Goldbeck et al. 2011).

Feral horses from the Mount Kundudo in eastern Ethiopia may have come from the Abyssinian-Adal War (1528 to 1560). The population sharply declined in recent decades, so that in 2022, only 30 individuals were still alive. The Ethiopian government has a plan to protect them in a national park for historical attest and as a tourist attraction (Kafena & Dessie 2011).

3.1.5. Wild Boar/Feral Pig *Sus scrofa*

The pig was introduced to sub-Saharan Africa by Neolithic farmers about 9000 BC. In South Africa, the Wild boar *Sus scrofa* was introduced for biological control against the Pine Tree Emperor larvae of *Nudaurelia cytherea* (Emperor Pine Moth; Lepidoptera: Sphingidae) in pine plantations of Tulbach (1926) and Franschoek (1941) in the Western Cape (Picker and Griffiths 2011; Skead et al. 2011). Feral pigs damage some critically endangered plants in the Western Cape, affecting succession and facilitating alien plant spread (Picker and Griffiths 2011). Eradicated from some areas, e.g. a total of 1209 feral pigs have been extirpated from the Kasteelberg area (van Wilgen and Wilson 2018). Also introduced to Gabon, Sudan, and Burkinia Fasso (Vercammen et al. 1993). Feral pigs are also present in Mafia and Pemba (Cuzin & Randi 2013).

3.1.6. Feral Goats *Capra hircus*

Apart from an established population on the Prince Edward Islands (Greve et al. 2020), feral populations are assumed to exist throughout South Africa. Feral goats grazing has reduced the cover and density of endemic geophytes and succulents shrubs in thicket vegetation, and conservation of this endemic-rich flora is seriously threatened (Moolman and Cowling 1994). It is responsible for desertification in the Sahel zone and other arid regions of Africa. It is regarded as one of the 100 worst invasive species in the world (IUNC 2025).

3.1.7. Other Feral Mammals

Some feral animals like Cattle *Bos taurus*, Sheep *Ovis aries* and Dromedary *Camelus dromedarius* may cause habitat degradation, However, their negative affect on vertebrate species has not been evidenced so far.

Table 1. Mammal species introduced in sub-Saharan Africa. Invasive species in bold case.

Scientific species name	Common species name	Family	Original range	Distribution in Africa
<i>Tenrec edacudaatus</i>	Common Tenrec	Tenrecidae	Madagascar and Comoros	Mauritius <1970; Reunion, <1882; Aldabra Atoll

<i>Suncus madagascariensis</i>	Madagascan Pygmy Shrew	Soricidae	Madagascar	Socotra, >1967
<i>Suncus etruscus</i>	Etruscan Shrew	Soricidae	Southern Palearctic	Socotra, <1967
<i>Suncus murinus</i>	Asian House Shrew	Soricidae	SE Asia	E Afr. Coast, Madagascar<1960, well-est.; Comoros, Mauritius, Reunion, est.??; Zanzibar, Pemba <1950 SA: Dyer Is. 1912; Aldabra Atoll
<i>Eulemur mongoz</i>	Mongoose Lemur	Lemuridae	Madagascar	Comoros, 1665; in 2000: 45 ind./km ² , 2008: 10 ind./km ² , 2019: 23 ind./km ² (L. J. Ormsby)
<i>Cercopithecus aethiops</i>	Green Monkey	Cercopithecidae	Africa	Cape Verde, 1960's
<i>Cercopithecus mona</i>	Mona Monkey	Cercopithecidae	Africa	São Tome e Principe, 1700-1800
<i>Erythrocebus patas</i>	Patas Monkey	Cercopithecidae	Africa	SA: KZN; 2000-2020; crop pest
<i>Macaca irus</i>	Long-tailed Macaque	Cercopithecidae	SE Asia	Mauritius Is. 1602; very invasive
<i>Macaca fascicularis</i>	Crab-eating Macaque	Cercopithecidae	SE Asia	Mauritius 1602; SA: W Cape
<i>Ovis aries musimon</i>	Mouflon	Bovidae	Palearctic	SA
<i>Ammotragus lervia</i>	Barbary Sheep	Bovidae	N Africa	SA: Tsolwana Game Reserve (E Cape, early 1980's), N Cape, F St. Total popul.: c. 1000 ind. in 2015 (S.Brady)
<i>Capra hircus</i>	Feral Domestic Goat	Bovidae	Iran	SA: 1650, escape; Nam (Damaral., Namal.); Assumption Is., <1897, 1895: 300-400 exx., 1916: only few, c. 1940 extinct; Prince Edward Is.; Aldabra, 1878, est., <1968 extinct; Mauritius, 1512, 1950: c. 100, <1982 extinct; São Tome e Principe, 16 th cen.
<i>Hemitragus jemlahicus</i>	Himalayan Tah	Bovidae	Himalayas; S Tibet, Nepal, India	SA 1930: Table Mts. (ornamental; 600 exx. 1974; 100 exx. 1981; 2000: 50-60 exx. eradicated), Cape Peninsula, Golden Gate, Free State. Vulnerable in India; but easy to keep in Zoos, reproduce efficiently
<i>Boselaphus tragocamelus</i>	Nilgai	Bovidae	India	SA: E. Cape, Free State
<i>Addax nasomaculatus</i>	Addax	Bovidae	N Africa	SA: FE, EC.
<i>Bison bison</i>	American Bison	Bovidae	N. America	SA: Ratelfontein near Richmond, Karoo,; 1990's +

<i>Bubalus bubalis</i>	Asian Water Buffalo	Bovidae	SE Asia	Namibia
<i>Bos frontalis</i>	Gaur	Bovidae	SE Asia	SA
<i>Antilope cervicapra</i>	Indian Blackbuck	Bovidae	India	SA: EC (escapee), 1985?
<i>Rusa unicolor</i>	Malayan Sambar	Cervidae	SE Asia	SA 1880 (hunting): EC; Mauritius: 1639 by Dutch
<i>Rusa timorensis</i>	Sunda Sambar	Cervidae	Indonesia	SA: EC c.1890; Reunion
<i>Cervus dama</i>	Fallow Deer	Cervidae	S Palearctic	SA 1869 (escapee): WC, EC, G, KZN, FS; Madagascar, 1932, extinct before 1974; Angola, Uganda
<i>Cervus axis</i>	Axis Deer	Cervidae	SE Asia	SA: EC<1985; FS; crop and forest pest
<i>Cervus nippon</i>	Sika Deer	Cervidae	Japan, China, Taiwan	SA: Groot Schuur, 1897, 1937: 20 exx.; EC, FS, Limp.; Madagascar, 1932, now extinct ; forest pest
<i>Cervus elaphus</i>	Wapiti	Cervidae	North America	Fernando Poo Isl. 1 (Gulf of Guinea), 1954, established? SA: FS near Clocolan, 1895, 1930's: 50 exx., Vereeniging (Transvaal), 1975; escapee
<i>Cervus elaphus</i>	Red Deer	Cervidae	Eurasia	SA: E Cape, Free State; escapee
<i>Cervus timorensis</i>	Rusa	Cervidae	SE Asia: Indonesia	Comoro Is., 1970; Madagascar, 1928, 1950's widespread, 1990's extinct; Mauritius, 1639, 1980's: c. 3000 exx.
<i>Cervus unicolor</i>	Samba	Cervidae	SE Asia	SA: Groot Schuur, 1897, 1930's: c. 50 exx.; 1990's in a few enclosures in WC
<i>Axis porcinus</i>	Hog Deer	Cervidae	India	SA---; escapee
<i>Elaphurus davidianus</i>	Père David's deer	Cervidae	China	SA: EC
<i>Sus scrofa</i>	Feral Domestic Pig	Suidae	Europe	SA 1926: W Cape, Zim, Tan. Ug, S Sud., Gabon, SE Chad; São Tome e Principe, 16 th cen.; Mauritius 1606, Reunion 1629, Rodrigues c. 1792
<i>Potamochoerus porcus</i>	Warthog	Suidae	Africa	Madagascar, <1962; Mayotte (Comoros), <1982
<i>Tayassus sp.</i>	Peccari	Tayassuidae	South America	Gabon: Wonga-Wongue Pres. Res., <1986
<i>Camelus dromedarius</i>	Dromedary Camel, feral	Camelidae	Asia	Socotra
<i>Equus asinus</i>	Feral Donkey	Equidae	C. Asia	SA: 1650, escape; Namib Desert and Ovamboland; Socotra; São Tome e Principe, 16 th cen.
<i>Equus ferus caballus</i>	Feral Horse	Equidae	C. Asia	SA: 1650, escape; Gabon: W.P. Game Res.<1986; established?; São Tome e Principe, 16 th cen.

<i>Equus africanus</i>	African Wild Ass, feral	Equidae	Africa	Socotra
<i>Canis familiaris</i>	Feral Dog	Canidae	Europe	Cape of Good Hope, <1970; São Tome e Principe, 16 th cen.; Madagascar, c.1000 BP
<i>Felis catus</i>	Feral Domestic Cat	Felidae	Europe	SA: 1650, escape; Marion 1949 to control rats (1977: 3409 exx.), Mauritius c.1685, Reunion c.1685, Rodrigues c.1745, Seychelles; São Tome e Principe, 16 th cen.; Mairon Isl. 1949 (+1991)
<i>Civettictis civetta</i>	African Civet	Viverridae	Africa	São Tome e Principe, 19 th cen.?
<i>Viverricula indica</i>	Small Indian Civet	Viverridae	SE Asia	Socotra, <1608; Zanzibar and Pemba, <1950; Madagascar <1950
<i>Urva auropunctatus</i>	Small Indian Mongoose	Herpestidae	SE Asia	Tanzania: Mafia, Zanzibar, Pemba, <1950; Mauritius <1985 (to control rats in sugar cane plantation)
<i>Herpestes edwardsi</i>	Grey Mongoose	Herpestidae	SE Asia	Mauritius, 1899 to control rats
<i>Mustela nivalis</i>	Weasel	Mustelidae	Europe	São Tome e Principe, 19 th cen.?
<i>Oryctolagus cuniculus</i>	European Rabbit	Leporidae	Europe	Robben Is.: 1652 (escapee of domestic ex.); many islands around S. Africa and Madag. 1860, now+; Cape Verde c.1450, abundant, 1990's+; Mauritius 1810, abundant, totally eradicated in 1987; Seychelles, 1980's but not established; Aldabra Atoll
<i>Lepus nigricollis</i>	Black-naped Hare	Leporidae	India, Pakistan	Mauritius, late 19 th cen., 1975: 650-1500 exx., 1982: 2450-2900 exx.; Cousin Is. (Seychelles): 1920's, 1971: 120-170 exx.; Madagascar; Reunion
<i>Mus musculus</i>	House Mouse	Muridae	Middle East	SA: c.800, stowaway; 1500's: Namibia, Zimbabwe, Kenya, DRC, Nigeria, Benin, Niger, Senegal, Mauritius, Marion, 1800's; São Tome e Principe, 16 th cen.
<i>Rattus norvegicus</i>	Brown Rat	Muridae	Far East	SA, 1650, stowaway; Mauritius 1735, Reunion 1735, Rodrigues <1874
<i>Rattus rattus</i>	House Rat	Muridae	SE Asia	SA: c. 800, stowaway; Madagascar, c.300 BC; SA; Mad, Tan, Moz, Et, Benin, Niger, Mauritius <1598, Reunion 1672, Rodrigues <1691, Mayotte, Comoros; São Tome e Principe, 16 th cen.
<i>Rattus tanezumi</i>	Asian House Rats	Muridae	SE Asia	Widespread in SA and Eswatini c. 2005

<i>Sciurus carolinensis</i>	Grey Squirrel	Sciuridae	USA, Canada	Cape Town area: 1890's, 1920's populated whole Cape Penis; Paarl: 1945; Ceres 1957; Swellendam: 1968
<i>Myocastor coypus</i>	Coypu	Echymyidae	S. America	Hanyunki (140 km N of Nairobi), c. 1940; Lake Naivasha: 1965; Lake Ol Bolossat, 1970; Tanz.; Zambia
<i>Hydrochoerus hydrochaeris</i>	Capybara	Caviidae	S. America	SA, c. 2020

Data from: Balleri et al. 2016, Bigalke & Pepler 1991, Brown et al. 1985, Crowford & Dyer 2000, De Villiers et al. 2010, Dobigny & Dalecky 2019, Dutton 1994, Feiler 1984, 1988, 2014, Frade 1958, Goodmann 2022, Greyling 2005, Goldbeck et al. 2011, Goodman 1995, Hinton & Dunn 1967, Hixton 2021, IUNC 2025, Jassat et al. 2013, Kafena, Dessie 2011, Kevley & Boshoffvan Wilgen et al. 2020, Kumschik & Nentwig 2010, Lever 1994, Nameer & Smith 2019, Nowak 1999, Picker & Griffiths 2011, 2017, Racamora & Henriette 2015, Russell et al. 2016, Ryan 2015, Sow & Duplantier 2023, Sussman & Tetrasell 1980, 1986, van Wilgen & Wilson 2018, van Wilgen et al. 2020.

3.2. Ungulates Introduced for Ranching and Hunting

3.2.1. Fallow Deer *Cervus dama*

It was introduced to South Africa to Cape Town in the 19th century and was slowly expanding around the city. By 1970 it occur all over the Western and Northern Cape (Skead et al. 2011). At the beginning of 21st, it occurs in all provinces of SA, except Limpopo (Picker and Griffiths 2011). Although the Fallow Deer is the most widely sold alien ungulate species in South Africa (Spear and Chown 2009a), only 11 game farms in this country are permitted to stock them (van Wilgen and Wilson 2018). Stable population occur also on Robben Island, South Africa.

3.2.2. Red Deer *Cervus elaphus elaphus*/Wapiti *C. e. canadensis*

Recently it was introduced to South Africa; earlier to Australia and New Zealand and to Argentina and Chile. It is regarded as one of the 100 worst invasive species in the world (IUCN 2025), but in sub-Saharan Africa it is not an invasive species

3.2.3. Sambar Deer *Rusa unicolor*

In the 1880's, it was introduced to the C. Rhode's Groote Schur estate in Cape Town, and from there it spread to Table Mountain in the Cape Peninsula (Picker and Griffiths 2011). Today it occurs in a woodlands of Orange Kloof and Twelve Apostles.

3.2.4. Himalayan Tahr *Hemitragus jemlahicus*

Himalayan Tahr are invasive on A small number of animals escaped from the Cape Town Zoo in the 1930s (Picker and Griffiths 2011) and invaded the Table Mountain section of Table Mountain National Park (Davies et al. 2020). The following numbers of the Himalayan Thar were recorded in the Table Mts., Western Cape: 1974: 600 animals, 1981: 100; 2000: c.40-50 (Walker 2001).

3.2.4. Other Species

The Muflon *Ovis aries musimn*, Barbary Sheep *Ammotragus lervia*, Nilgai *Boselaphus tragocamelus*, American Bison *Bison bison*, Asian Water Buffalo *Bubalus bubalis*, Gaur *Bos frontalis*, Indian Blackbuck *Antelope cervicapra*, Addax *Addax nasomaculatus*, Sunda Sambar *Rusa timorensis*, Axis Deer *Cervus axis*, Sika Deer *Cervus nippon* have been introduced for hunting

purposes and kept in enclosures, mostly in South Africa. Some of them may escape from the enclosures and disperse in natural habitats, but such incidental 'introductions' are unsuccessful in most cases.

3.3. *Leporids*

3.3.1. European Rabbit *Oryctolagus cuniculus*

In 1658, successful introduction to Robben Island. In 2009, the population on Robben Island was estimated to exceed 24,000 individuals (de Villiers et al. 2010). Rabbits have been introduced to all islands off the South African coast, and still occur on Jutten, Dassen, Vondeling, Schaapen, Bird and Seal Islands (Cooper and Brooke 1982). Brooke et al. (1986) suggested that rabbits remain unsuccessful on the mainland as there are too many natural predators. The rabbits on Schaapen Island are currently all albino, while by 1977 the rabbits on Meeuw Island had become extinct. (Cooper and Brooke 1982).

In 17th century introduced (and now present) to several small, not populated islands along the coast in South Africa and Namibia: Robben, Jutten, Schappen, Vondelling, Dassen near Cape Town; Bird near Port Elizabeth; Possession near Lüderitz. It was introduced also to several other small islands near South African coast, but now it is extinct there (Happold 2013e).

The rabbit is regarded as one of the 100 worst invasive species in the world (IUNC 2025). In 1996, it was successfully removed from Birds Island, Seychelles, and in 1998, from the Gunners Quoins. By the year 2019, about 13,000 rabbits were eliminated from the Robben Island (Davies et al. 2020).

3.3.2. Black-Footed Hare *Lepus nigricollis*

It is native to the Indian subcontinent. It has been introduced to Madagascar, Seychelles, Comoros, Mauritius, Reunion and Mayotte. Since its' introduction to Mauritius it has become an agricultural pest (Owadally 1980). On Cousin Island their browsing prevent the regeneration of *Casuarina equisetifolia*, which provide staple food for some endemic terrestrial birds (Kirk and Racey 1992).

3.4. *Rodents*

European ships brought with early invaders, such as rats and mice, although there are evidences that rats *Rattus* spp. and mouse were present long before this contacts began. The increasing commerce of alien pets in South Africa (mainly rodents), causes increasing amounts of escapees in the wild (Measey et al. 2020).

It should be emphasized that the introduction of mice and rats has been followed in many instances by the introduction of cats to control them, and their impacts may become reinforced/amplified.

Three alien murid rodent species, viz Black Rat, Brown and House Mouse have caused local extinctions of native species of invertebrates, birds, bats and rodents on several islands through predation, competition for food, and disease transmission (e.g. Steadman 1995; Courchamp et al. 2003; Harris 2009).

The focal species Black Rat *Rattus rattus*, Brown Rat (or Norway Rat) *R. norvegicus*, Pacific Rat *R. exulans* and House mouse *Mus musculus* are implicated in at least 11 extinctions. Today, over 80% of the world's major island groups host at least one of the rat trio (*R. rattus*, *R. norvegicus*, *R. exulans*) reviewed here (Atkinson 1985; Russell et al. 2008). They pose a major threat to native biota throughout the world (reviewed in Atkinson 1985; Courchamp et al. 2003; Towns et al. 2006; Jones et al. 2008). It is interesting that the Black Rat is implicated in the majority of impacts. This may be explained by its extensive distribution and ecological plasticity.

3.4.1. House Mouse *Mus musculus*

On the mainland, its impact appears to be mostly socio-economic (moderate) (Hagen and Kumschick 2018), including spoiling of stored foods. The House Mouse was introduced also to many islands. Among others it was introduced accidentally to Marion Island (before 1818), as a stowaway on ships (Watkins and Cooper 1986). On the island, it preys on invertebrates (Jones and Ryan 2010; Dilley et al. 2016) and this changed the population densities, reproduction strategies and growth rates of some invertebrates on the island (Treasure and Chown 2014). Similarly, declines in albatross populations, and other colonially breeding marine birds, have been attributed to predation of eggs and chicks by the House Mouse (Dilley et al. 2016).

3.4.2. Black Rat (House Rat) *Rattus rattus*

The House Rat, called also Black Rat, could have been introduced to South Africa in pre-historical times (700–800 AD; Deacon 1986). House rats were reported to be abundant on Robben Island from 1614 (Crawford and Dyer 2000). It has invaded considerably into the African interior (Monadjem et al. 2015). Introduced by Arab and Europeans' ships, and then by dispersed by rivers, railways and roads. It was recorded in Mombasa and Dar es Saalam in 1895, Tabora: 1895, Kisumu: 1901, Kampala: 1911, Serengeti: 1976, eastern DRC: 1950's. It is very common in optimal habitats, but it is characterized by big seasonal and yearly variations in numbers. In Lagos, Nigeria, in 1931–34, the proportion of *R. norvegicus* to *R. rattus* was 5: 95. (Happold 2013b). Recently, it was recorded also in south-western Niger (Dobigny et al., 2011). The Black Rat has colonized, in fact, most of the world following ship-mediated trade. It is regarded as one of the 100 worst invasive species in the world (IUNC 2025).

3.4.3. Brown Rat *Rattus norvegicus*

It was introduced to South Africa via ship traffic between Asia and Europe in 16th century (Skead et al. 2011). It is a strongly commensal species occurring mostly on the coastal port and urban areas. Confined to coastal ports, Recorded in Bamako on the Niger River in 2000. Introduced mainly in 19th and 20th cent. (Happold 2013c). In sub-Saharan Africa, the Brown Rat is limited to coastal areas, while the Black Rat is more widely distributed but restricted by the drier areas (De Graaff 1981). The two rat species are widely regarded as pests. In South Africa, specifically, they damage infrastructure, contaminate foodstuffs, and act as reservoirs of zoonotic diseases (e.g. Jassat et al. 2013; Julius et al. 2018; Potgieter et al. 2020). The zoonotic diseases, such as plague (caused by the bacillus *Yersinia pestis* transmitted from rats via fleas to humans), leptospirosis, toxoplasmosis (Taylor et al. 2008). They also carry several co-invasive parasites (Julius et al. 2018a, b). *Bartonella* and *Helicobacter* were recorded in all three rat species in South Africa (van Helden et al. 2020).

3.4.4. Grey Squirrel *Sciurus carolinensis*

It was introduced from N. America via UK, in c. 1890 to Cape Town (Smithers 1983). Today, it is confined to an area of c. 7000 km² around Cape Town, Stellenbosch, Paarl, Eldin, Swellendam and Ceres. It inhabits urban, agricultural and afforested environment. It is fairly common, but no estimation of its population is available (Happold 2013a). The Grey Squirrel is indigenous to USA and Canada. It is regarded as one of the 100 worst invasive species in the world (IUNC 2025), but no damage is recorded in South Africa.

3.4.5. Asian House Rat *Rattus tanezumi*

In the recent decades, the Asian House Rat has been introduced in South Africa. Today, it appears to be widespread throughout both South Africa and Swaziland (Bastos et al. 2011).

3.4.6. Coypu *Myocaster coypus*

The Coypu has been introduced in Nanyuki, central Kenya in 1947; c. 1950 it was released / escaped and spread in the Central Highlands east of the Rift Valley. In 1960's it has invaded the Lake Naivasha in the Rift Valley. It was released in 1960's in Zambia, NE Tanzania, Botswana, Zimbabwe, South Africa. However, the introductions has failed (Happold 2013d).

3.4. Carnivores

Three Oriental small carnivores: Small Indian Civet *Viverricula indica*, Small Indian Mongoose *Urva auropunctatus* and Grey Mongoose *Herpestes edwardsi*, were introduced to Tanzanian islands: Mafia, Zanzibar and Pemba. They may pose serious threat to the local herpetofauna, although these are no evidence of their negative role.

The Small Indian Mongoose has decimated partridges, quails and black-naped hares *Lepus nigricollis* (an introduced species), and has contributed to the extirpation of the Timor Deer that was introduced to Mauritius, and Reunion island in 1639 from Batavia (Hinton and Dunn 1967; Lever 1994). It is regarded as one of the 100 worst invasive species in the world (IUNC 2025).

There are also two carnivores in São Tomé, the African Civet *Civettictis civetta* and the Least Weasel *Mustela nivalis* (Bocage, 1904b; Frade, 1958) which are suspected to cause a decline of some endangered endemic species.

3.5. Primates

Four African primate species, the Mona Monkey *Cercopithecus mona*, Mongoose Lemur *Eulemur mongoz*, Green Monkey *Cercopithecus aethiops*, and Patas Monkey *Erythrocebus patas*; and two primate species from the Oriental Region, the Long-tailed Macaque *Macaca irus*, and Crab-eating Macaque *Macaca fascicularis* were introduced mainly to small oceanic islands, and to the southern and eastern Africa (Bocage, 1904a,b; Frade, 1958; Feiler, 1984, 1988; Feiler et al., 1993; Sussman 1980, 1986).

The impact of the Crab-Eating Macaque *Macaca fascicularis* is not well documented in South Africa. As generalist feeder, it is highly adaptable species. It is suspected to negatively affect threatened birds by destroying their nests with eggs or chicks. They also may compete for fruits with some frugivorous bird species (Sussman 1980, 1986). It is listed among 100 worst invasive species of the world (IUCN 2025).

3.6. Insectivores

Two *Suncus* shrews, namely the Etruscan Shrew *Suncus etruscus* from southern Palearctic Region and Madagascan Pygmy Shrew *Suncus madagascariensis* from Madagascar were introduced to Socotra Island. Other species of this genus, the Asian House Shrew *Suncus murinus* from the Oriental Region was introduced to East Africa, Madagascar and surrounding islands. The Common Tenrec *Tenrec ecaudatus* has been introduced to the Mascarenes. With the help of the introduced frog *Rana mascariensis*, tenrecs are reported to cause extinction of three endemic frogs, viz. *Sooglossus thomasetti*, *Sooglossus sechellensis* and *Sechellophryne gardinieri* on the Seychelles (Lever 1994).

3.7. General Characteristics of the Mammal Introductions in Sub-Saharan Africa

A total of 56 mammal species belonging to 20 families have been hitherto introduced to sub-Saharan Africa. Most were representatives of the following orders: Artiodactyla (n = 26, including Cervidae – 12 spp. and Bovidae – 9 spp.), Carnivora (n = 7) and Primates (n = 6).

Most species introduced to sub-Saharan Africa originated from the Oriental (n = 20) and Palearctic Region (n = 19). Also from other regions of Africa (n = 9), Nearctic (n = 3) and Neotropics (n = 3).

Only species, two House Mouse and Black Rat, have been introduced before 1400 (probably as early as 800 AD); five other were introduced between 1401 and 1700. The first half of the 17th century saw the highest number (n = 11) of introduced species. While during the years 1651 and 1850, only

two species were introduced. In the following 175 years (1851-2025) as many as 24 species were introduced to sub-Saharan Africa and the trend is increasing (Figure 1).

Ten of the introduced mammal species, namely *Sus scrofa*, *Capra hircus*, *Rattus rattus*, *R. norvegicus*, *Mus musculus*, *Felis catus*, *Canis familiaris*, *Viverricula indica*, *Urva auropunctata* and *Maccaca fuscicularis* become invasive species in sub-Saharan Africa (van Wilgen and Wilson 2018).

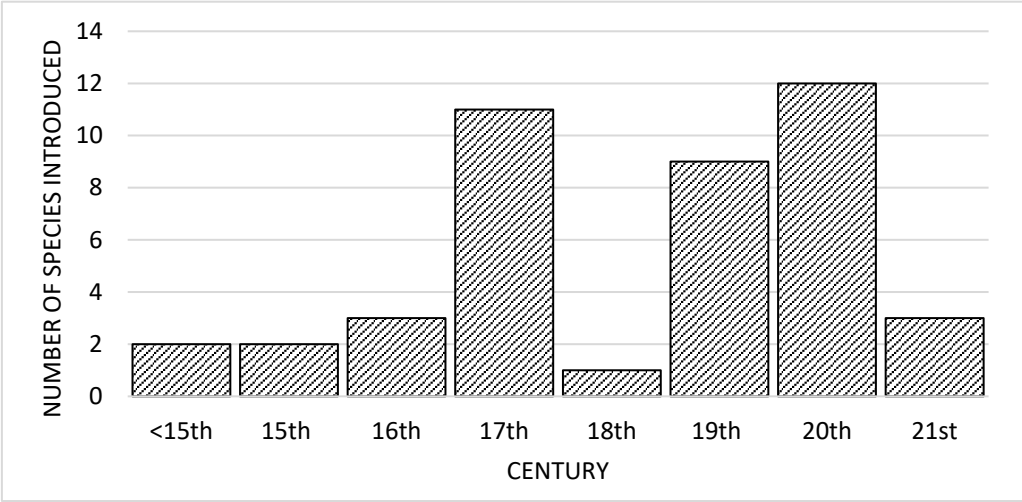


Figure 1. Known years of introduction of mammals in sub-Saharan Africa.

4. Relocated Mammal Species in Sub-Saharan Africa

Some mammal species, especially representative of the game animals, were relocated within or close to their original range, usually within the same or similar vegetation type (e.g. within savanna). They are kept in enclosures and their numbers are strictly controlled. These animals were actually not introduced but relocated. Most of these relocations took place in South Africa and Namibia. A number of various mammal species were also relocated from Tanzanian interior to a small island Rubondo (240 km²), on the Lake Victoria. Most animals relocated there are representatives of the family Bovidae (Artiodactyla), with some species from the orders Perissodactyla and Primates, and single species from other orders.

A total of 39 mammal species were relocated within sub-Saharan Africa. Most of them were representatives of the family Bovidae (76.9%), and only 7.7% for each order Parissodactyla and Primates. The number may be even higher than listed in Table 2, as many of relocations may pass unrecorded. It should be mentioned that some of the relocated mammals may escape from enclosure or purposefully released and develop a viable population. In this way they may became introduced or even invasive species.

There is a striking disproportion in the composition of relocated versus introduced mammal species, while 46% introduced species belong to Artiodactyla, as many as 79% of relocated species belong to this order. No Rodentia and Eulypotyphla species were relocated, while they comprise 13% and 9% respectively of all introduced mammal species.

The main problem of relocated species is linked with gene pollution. Relocation may lead to hybridizations between two subspecies, which are often released to the same area, e.g. *Hippotragus equinus*, *Kobus ellipsyprimnus*, *Aepyceros melampus*, *Equus zebra*, *Equus burchelli*, *Ceratotherium simum*.

One of the most interesting mammal species relocated is the Roan Antelope *Hippotragus equinus*. It has been estimated that only 300 roan antelopes are living in the wild in South Africa, while the remainder (c. 3500) are stock on ranches (Havemann et al. 2016). Most of the ranched Roan Antelopes are now extralimital to the natural distribution of *Hippotragus equinus equinus*, in the northern part of the Limpopo province, South Africa (Kruger et al. 2016). The popularity of this species in the game industry has given rise to concerns for its genetic integrity, as imported *Hippotragus equinus koba*, from

West Africa hybridize with native *Hippotragus equinus equinus* (Mathee and Robinson 1999; Castley et al. 2001; Alpers et al. 2004; van Wyk et al. 2019).

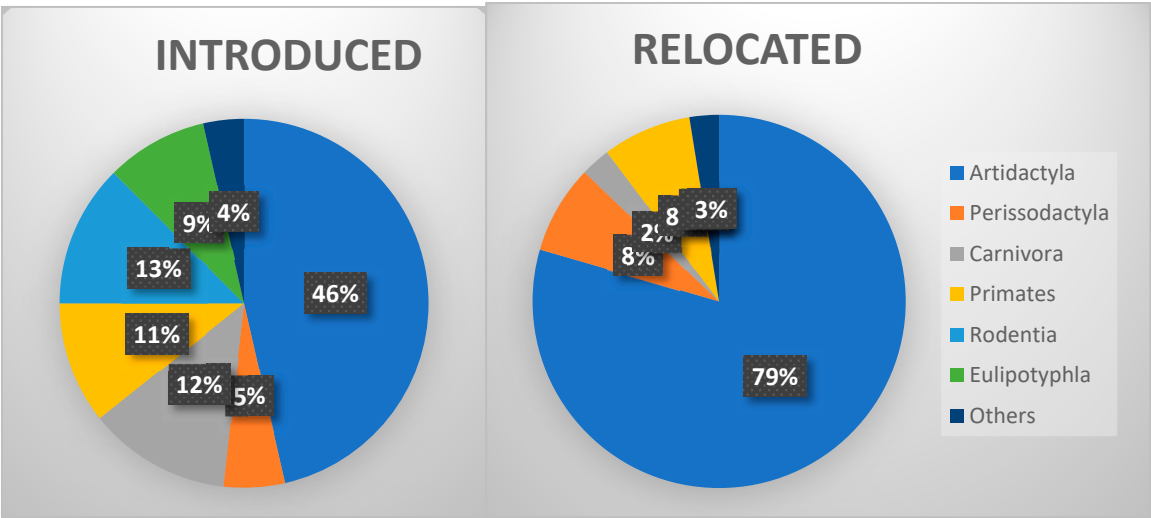


Figure 2. Proportions of particular orders of relocated (n = 39 species) and introduced (n = 56 species) mammals in sub-Saharan Africa.

Table 2. Introduced/translocated/escaped from captivity, did not established viable population, or established it but now regarded extinct.

Species scientific name	Species common name	Family	Original range	Translocated to
<i>Kobus ellipsiprymnus ellipsiprymnus</i>	Waterbuck	Bovidae	South Africa	Nam., Senegal
<i>Kobus vardonii</i>	Puku	Bovidae	South Africa	South Africa
<i>Kobus leche</i>	Lechwe	Bovidae	South Africa	South Africa
<i>Syncerus caffer</i>	African Savanna Buffalo	Bovidae	Africa	South Africa, Namibia
<i>Aepyceros melampus petersi</i>	Black-faced Impala	Bovidae	Namibia, Angola	Angola, Namibia
<i>Antidorcas marsupialis</i>	Springbok	Bovidae	South Africa	South Africa, Namibia
<i>Redunca arundineum</i>	Common Reedbuck	Bovidae	South Africa	Namibia
<i>Redunca fulvorufula</i>	Mountain Reedbuck	Bovidae	South Africa	Namibia
<i>Pelea capreolus</i>	Grey rhebok	Bovidae	South Africa	South Africa

<i>Oryx dammah</i>	Scimitar-horned Oryx	Bovidae	N Africa	South Africa
<i>Oryx gazella gazella</i>	Southern Oryx	Bovidae	South Africa	Senegal
<i>Tragelaphus derbianus</i>	Derby's Eland	Bovidae	C and W Africa	South Africa
<i>Tragelaphus euryceros</i>	Bongo	Bovidae	Central Africa	South Africa
<i>Tragelaphus imberbis</i>	Lesser Kudu	Bovidae	NE Africa	South Africa
<i>Tragelaphus scriptus</i>	Greater Kudu	Bovidae	South Africa	South Africa; Tanzania: Rubondo (240 km ²), Lake Victoria island
<i>Tragelaphus angasi</i>	Nyala	Bovidae	South Africa	Botswana, Namibia, Angola
<i>Tragelaphus spekii</i>	Sitatunga	Bovidae	Southern Africa	South Africa; Tanzania: Rubondo (240 km ²), Lake Victoria island
<i>Taurotragus oryx oryx</i>	Common Eland	Bovidae	Southern Africa	Senegal
<i>Cephalophus natalensis</i>	Natal Duiker	Bovidae	South Africa	South Africa
<i>Neotragus moschatus</i>	Suni	Bovidae	South Africa	South Africa, Tanzania: Rubondo (240 km ²), Lake Victoria island
<i>Madoqua kirkii</i>	Kirk's Dik-dik	Bovidae	E Africa	South Africa
<i>Capra ibex</i>	Nubian Ibex	Bovidae	NE Africa	Namibia
<i>Hippotragus niger</i>	Sable Antelope	Bovidae	Botswana, Namibia, Angola	South Africa
<i>Hippotragus equinus koba</i>	Roan Antelope	Bovidae	West Africa	South Africa; Tanzania: Rubondo (240 km ²), Lake Victoria island
<i>Damaliscus pygargus dorcas</i>	Bontebok	Bovidae	South Africa	South Africa
<i>Damaliscus pygargus phillipsi</i>	Blesbok	Bovidae	NE South Africa	SW South Africa, Botswana, Moz., Namibia, Zimbabwe, Angola
<i>Beatragus hunteri</i>	Hirola	Bovidae	SE Kenya	W Kenya (Tsavo)
<i>Oreotragus oreotragus</i>	Klipspringer	Bovidae	South Africa	South Africa

<i>Connochaetes gnou</i>	Black Wildebeest	Bovidae	Africa	Namibia
<i>Connochaetes taurinus</i>	Blue Wildebeest	Bovidae	Africa	Gabon: WW P.R., <1986, now??
<i>Giraffa camelopardalis</i>	Giraffa	Giraffidae	South Africa	South Africa; Tanzania: Rubondo (240 km ²), Lake Victoria island
<i>Equus zebra hartmannae</i>	Hartmann's Mountain Zebra	Equidae	Namibia	South Africa: Western cape, Eastern Cape
<i>Diceros bicornis michaeli</i>	Black Rhinoceros	Rhinocerotidae	Kenya	South Africa; Tanzania: Rubondo (240 km ²), Lake Victoria island
<i>Ceratotherium simum simum</i>	White Rhinoceros	Rhinocerotidae	South Africa, Kenya	Uganda, Kenya, Zambia
<i>Loxodonta africana</i>	African Elephant	Loxodontidae	Africa	Tanzania: Rubondo (240 km ²), Lake Victoria island
<i>Panthera leo melanochaita</i>	African Lion	Felidae	South Africa	Rwanda
<i>Colobus abyssinicus</i>	Angola Pied Colobus	Cercopithecidae	Central Africa	Tanzania: Rubondo (240 km ²), Lake Victoria island
<i>Cercopithecus aethiops</i>	Vervet Monkey	Cercopithecidae	Africa	Tanzania: Rubondo (240 km ²), Lake Victoria island
<i>Pan troglodytes</i>	Chimpanzee	Hominidae	Central Africa	Tanzania: Rubondo (240 km ²), Lake Victoria island

Data from: Bomer 1988, Gippoliti et al. 2021, Bromer 1988, Hoveman et al. 2016, Kikot & Nushi 2025, Shivumbu et al. 2021, Spear & Chown 2008, 2009a, 2009b, van Wyk et al. 2019. Invasives South Africa. <https://invasives.org.za/national-list-of-invasive-mammal-species/> Accessed 19.02.2025.

5. Impacts of Introduced Mammals on the Vertebrate Biodiversity

In sub-Saharan Africa, at least 144 vertebrate species represented by 52 families were affected by alien mammals, 3 amphibian, 23 reptiles, 89 birds and 29 mammals. No fish were recorded as negatively affected by alien mammals. Among reptiles the most speciose were Scincidae (n = 11) and Testudinidae (n = 6); among birds Procellariidae (n = 9), Columbidae (n = 9) and Rallidae (n = 9), while among mammals three lemur families: Palaeopropithecidae, Megalodapidae and Archeolemuridae (N = 11).

Based on published records of impacts exerted by alien mammals on the vertebrate fauna of the sub-Saharan Africa, the following mechanisms may be distinguished: predation, competition, hybridization, transmission of diseases and parasites; habitat destruction (grazing / herbivory / browsing).

Most vertebrate species (79.4%) were affected by alien mammals through direct predation. Alien mammals has caused habitat destruction for only 10 (7.1%) vertebrate species. Other effects (competition and genetic pollution) were marginal (3.5%). Predation by alien mammals affected 13 (72.2%) reptile species, 82 (92.1%) bird species, and 17 (54.8%) mammal species. Most affected species (83.0%) were endemic to small oceanic islands. Nineteen (13.5%) were marine bird species from 8 families (e.g. Procellariidae, Sulidae and Laridae) and only five affected mammal species (3.5%; including three species from the genus *Equus*) were not endemics.

As result of mammal introduction, 65 species in sub-Saharan Africa became globally extinct, 45 are threatened (included in Red Data Books) and 31 other species are in decline, although not included in Red Data Book/List. Among extinct species, 10 are reptiles, 37 birds and 18 mammals. Threatened species include 9 reptiles, 31 birds and 5 mammals. Most declining species are birds (n = 21), with few mammals (n = 6), reptiles (n = 4) and amphibians (n = 3). No fish species were found as affected negatively by alien mammals. It should be, however, emphasized that many of these species were affected negatively not only by alien mammal species, but often directly by man through excessive hunting and habitat destruction.

Most extinct birds were affected by introduced rats, mouse and feral cats (Figure 3). They affected other vertebrate species through predation, acting often together, as a kind of deadly trio. At least 25 bird species were affected in such a way, while additional 23 bird species – by both cats and rats, but without mouse. These three invasive species are especially destructive to the endemic vertebrate fauna on small oceanic islands. Among carnivores, very destructive are also feral dogs. They have affected at least 34 vertebrate species. Unlike rodents, feral dogs affect mainly mammals (n = 20 species). They were the ultimate cause of the global extinction of at least 14 giant lemurs in Madagascar. In some regions of Africa, the feral dog may transmit rabies to other carnivore species, especially the endangered Ethiopian Wolf *Canis simensis*, and other members of the family Canidae (Macpherson et al., 1983; Dohery et al. 2017). There only two wild carnivores introduced to sub-Saharan Africa: the Small Indian Mongoose and Small Indian Civet. The former species affect negatively at least six bird species, while the later one proved to be destructive to only one species, the vulnerable Socotra Bunting *Emberiza socotrana*.

Other group of introduced mammals affect negatively the sub-Saharan African vertebrate fauna mainly through habitat destruction. Three of them became especially destructive: the Feral Goat, Feral Pig, and European Rabbit. The Feral Pig may also affect some ground-dwelling species through direct predation. It was found especially destructive to land tortoises in Seychelles, causing global extinction of several species.

Table 3. Vertebrate species threatened by alien mammal species in sub-Saharan Africa.

Species scientific name	Common scientific name	Family	RDB status	Effects	Place	Alien mammals	Source
AMPHIBIA							
<i>Sooglossus thomasetti</i>	Thomasset's Seychelles Frog	Sooglossidae	E, CR	P**	Seychelles	<i>Tenrecus ecaudatus</i>	Lever 1994
<i>Sooglossus sechellensis</i>	Seychelles Frog	Sooglossidae	E, EN	P**	Seychelles	<i>Tenrecus ecaudatus</i>	Lever 1994
<i>Sechellophryne gardinieri</i>	Gardiner's Seychelles Frog	Sooglossidae	E, EX	P**	Seychelles	<i>Tenrecus ecaudatus</i>	Lever 1994
REPTILIA							

<i>Casarea dussumieri</i>	Round Island keel-scaled Boa	Bolyeriidae	E, EX 1975	H***	Mauritius: Round Island	Goat, rabbit, hare	Cheke and Hume (2008)
<i>Madatyphlops cariei</i>	Hoffstetter's worm snake	Typhlopidae	E, EX c.1800	P***	Mauritius	Cat, dog, other intr. carnivores	Cole 2021
<i>Chioninia coctei</i>	Cape Verde Giant Skink	Scincidae	E, EX:1996	P**	Cape Verde	(Dog, cat)	Mateo et al. 2020
<i>Gongylomorphus bojeri</i>	Bojer's Skink	Scincidae	E, CR	H**	Mauritius: Round Island	<i>Suncus murinus</i> (goat, rabbit)	Cheke and Hume (2008)
<i>Gongylomorphus fontenayi</i>	Orange-tailed Skink	Scincidae	E, EN	P, H**	Mauritius: Gunner's Quoin	Rat, hare, rabbit	Cheke and Hume (2008)
<i>Leiolopisma ceciliae</i>	Reunion Giant Skink	Scincidae	E, EX c.1700	P**	Reunion	Rats (intr.1670)	Sanchez et al. 2020
<i>Leiolopisma mauritiana</i>	Mauritian Giant Skink	Scincidae	E, EX?	P**	Mauritius	Rats?	WCMC 1996
<i>Leiolopisma telfairii</i>	Telfair's Skink	Scincidae	E, VU	H*	Mauritius: Round Is., G. Quoin	Goat and rabbit	Cheke and Hume (2008)
<i>Phelsuma gigas</i>	Rodrigues giant day gecko	Scincidae	E, EX 1842	P***	Rodrigues, Frigate Is.	Brown Rat	WCMC 1996
<i>Trachylepis comorensis</i>	Comorian Skink	Scincidae	E, LC	P***	Comoros, Moz., Madagascar	Rats	Animalia.bio.comoros
<i>Trachylepis socotrana</i>	Socotra Skink	Scincidae	E, LC	P*	Socotra	Cat, Rat, Mouse	Animalia.bio.socotra
<i>Nactus durrelli</i>	Durrell's Night gecko	Gekkonidae	E, VU	H**	Mauritius: Round Island	Goat, rabbit	Cheke and Hume (2008)
<i>Nactus coindemirensis</i>	Lesser Night Gecko	Gekkonidae	E, VU	P, H**	Mauritius: Gunner's quoin	Rat, hare, rabbit	Cheke and Hume (2008)
<i>Phelsuma guentheri</i>	Günther's Gecko	Gekkonidae	E, EN	H**	Mauritius: Round Is., Il. Aigrettes	Goat, rabbit	Cheke and Hume (2008)
<i>Tarentola gigas</i>	Cape Verde Giant Gecko	Phyllodactylidae	E, EN	P***	Cape Verde	<u>Cats</u> , rat, mouse	Delgado et al. 2021
<i>Psammobates geometricus</i>	Geometric Tortoise	Testudinidae	E, CR	P*	SA: W. Cape	Feral pig, cat	Measey et al. 2020

<i>Aldabrachelys abrupta</i>	Abrupt giant tortoise	Testudinidae	E, EX 1230-1315	P*	Madagascar	Feral pig, cat	Kehlmaier et al. 2023
<i>Aldabrachelys gigantea daudinii</i>	Daudin's giant tortoise	Testudinidae	E, EX c.1850	P*	Seychelles: Mahe	Feral pig, cat	Rhodin et al. 2015
<i>Cylindraspis indica</i>	Réunion giant tortoise	Testudinidae	E, EX c.1840	P*	Reunion	Feral pig, cat	Rhodin et al. 2015
<i>Cylindraspis inept</i>	Mauritius Giant Tortoise	Testudinidae	E, EX 1844	P*	Mauritius	Feral pig, cat	Rhodin et al. 2015
AVES							
<i>Hirundo atrocaerulea</i>	Blue Swallow	Hirundinidae	E, EN	H*	SA: Mpumalanga	Feral Horse	Measey et al. 2020
<i>Terpsiphone corvina</i>	Seychelles Black Parad. Flycatcher	Monarchidae	E, VU	P*	Seychelles: La Digue	Cat, rat	Rocamora and Henriette (2015)
<i>Copsychus sechellarum</i>	Seychelles Magpie Robin	Muscicapidae	E, EN	P*	Seychelles: Aride Denis, Frégate,	Cat, rat	Rocamora and Henriette (2015)
<i>Humboldia flavirostris</i>	Humbolt's Flycatcher	Muscicapidae	E, VU	P, C*	Comoros	Black Rat, Com. Myna?	Animalia.bio.comoros
<i>Coracina newtoni</i>	Réunion Cuckooshrike	Campepha-gidae	E, CR	P, H*	Reunion	Rat, cat, (deer)	Ghestemme and Salamolard (2007)
<i>Zosterops modestus</i>	Seychelles White-eye	Zosteropidae	E, VU	P*	Seychelles	Cat, rat	Rocamora and Henriette (2015)
<i>Zosterops chloronothos</i>	Mauritius Olive White-eye	Zosteropidae	E, CR	P*	Mauritius: Ile aux Aigrettes	Rat, cat, mongoose	Cheke and Hume (2008)
<i>Zosterops semiflavus</i>	Marianne white-eye	Zosteropidae	E, EX 1892	P**	Seychelles: Marianne Isl.	Blak rat	Hume 2017
<i>Acrocephalus sechellensis</i>	Seychelles Warbler	Acrocephalidae	E, NT	P*	Seychelles	Cat, rat	Rocamora and Henriette (2015)
<i>Nesillas aldabrana</i>	Aldabra Brush Warbler	Acrocephalidae	E, EX 1994	P, H**	Seychelles: Aldabra	Rat, cat, goat	BL Int. 2016
<i>Foudia sechellarum</i>	Seychelles Fody	Ploceidae	E, NT	P*	Seychelles: Denis	Cat, rat	Rocamora and Henriette (2015)
<i>Foudia rubra</i>	Mauritius Fody	Ploceidae	E, EN	P**	Mauritius: Ile aux Aigrettes	Rat, cat, mongoose	Cheke and Hume (2008)

<i>Foudia delloni</i>	Reunion Fody	Ploceidae	E, EX 1675- 1680	P*	Reunion	Rats	Cheke 2013
<i>Onychognathus frater</i>	Socotra Starling	Sturnidae	E, LC	P*	Socotra	Cat	Animalia.bio.socotra
<i>Necropsar rodericanus</i>	Rodrigues Starling	Sturnidae	E, EX 1726	P*	Rodrigues	Rat	Cheke 2013
<i>Fregilupus varius</i>	Hoopoe Starling	Sturnidae	E, EX 1837	P, H*	Reunion	Rat, cat, goat?	BL Int. 2016
<i>Chalcomitra balfouri</i>	Socotra Sunbird	Nectariniidae	E, LC	P*	Socotra	Cat	Animalia.bio.socotra
<i>Hypsipetes cowlesi</i>	Rodrigues Bulbul	Pycnonotidae	E, EX+?	P*	Rodrigues	Rat?	Cheke 2013
<i>Cisticola haesitatus</i>	Socotra Cisticola	Cisticolidae	E, LC	P*	Socotra	Cat	Animalia.bio.socotra
<i>Incana incana</i>	Socotra Warbler	Cisticolidae	E, LC	P*	Socotra	Cat	Animalia.bio.socotra
<i>Passer insularis</i>	Socotra Sparrow	Passeridae	E, LC	P*	Socotra	Cat	Animalia.bio.socotra
<i>Rhynchostruthus socotranus</i>	Socotra Golden- winged Grosbeak	Fringillidae	E, LC	P*	Socotra	Cat	Animalia.bio.socotra
<i>Emberiza socotrana</i>	Socotra Bunting	Emberizidae	E, VU	P**	Socotra	Cat, Rat, Indian Small Civet	Animalia.bio.socotra
<i>Phaethon aethereus</i>	Red-billed Tropicbird	Phaethonti-dae	LC	P**	Cape Verde	<u>Cat</u> , dog, rat, mouse	Sanchez 2020; Semedo et al. 2020
<i>Phaethon lepturus</i>	White-tailed Tropicbird	Phaethonti-dae	LC	P*	Seychelles: Ile du Nord	Rat	Rocamora and Henriette (2015)
<i>Sula dactylatra</i>	Masked Booby	Sulidae	LC	P*	Seychelles: Grande Ile	Rat	Rocamora and Henriette (2015)
<i>Sula leucogaster</i>	Brown Booby	Sulidae	LC	P**	Tromelin Island	<u>Cat</u> , dog, rat, mouse	Semedo et al. 2020
<i>Papasula abbottii</i>	Abbott's Booby	Sulidae	EN	P**	Mascarenes, +c.1670	(Monkey)	Cheke 2013
<i>Hydrobates jabejabe</i>	Cape Verde Storm-petrel	Hydrobatidae	E, NT	P**	Cape Verde	<u>Cat</u> , dog, rat, mouse	Sanchez 2020; Semedo et al. 2020
<i>Pelagodroma marina</i>	White-faced Storm-petrel	Procellariidae	LC	P**	Cape Verde	<u>Cat</u> , dog, rat, mouse	Sanchez 2020; Semedo et al. 2020
<i>Calonectris edwardsii</i>	Cape Verde Shearwater	Procellariidae	E, NT	P**	Cape Verde	<u>Cat</u> , dog, rat, mouse	Sanchez 2020; Semedo et al. 2020

<i>Bulweria bulwerii</i>	Bulwer's Petrel	Procellariidae	LC	P**	Cape Verde	Cat, dog, rat, mouse	Sanchez 2020; Semedo et al. 2020
<i>Pterodroma feae</i>	Cape Verde Petrel	Procellariidae	E, NT	P**	Cape Verde	Cat, dog, rat, mouse	Sanchez 2020; Semedo et al. 2020
<i>Puffinus lherminieri boydi</i>	Boyd's Shearwater	Procellariidae	E, LC	P**	Cape Verde	Cat, dog, rat, mouse	Sanchez 2020; Semedo et al. 2020
<i>Fregata magnificens</i>	Magnificent Frigatebird	Procellariidae	LC	P**	Cape Verde	Cat, dog, rat, mouse	Sanchez 2020; Semedo et al. 2020
<i>Ardenia pacifica</i>	Wedge-tailed Shearwater	Procellariidae	LC	P*	Seychelles	Rat	Rocamora and Henriette (2015)
<i>Ardenia pacifica</i>	Wedge-tailed Shearwater	Procellariidae	LC	H*	Mauritius: Round Island	Goat, rabbit	Cheke and Hume (2008)
<i>Pseudobulweria aterrima</i>	Mascarene Black Petrel	Procellariidae	E, CR	P*	Rodrigues	Cat?	Cheke 2013
<i>Leucocarbo melanogenis</i>	Crozet Shag	Phalacrocoracidae	NE, CR	P**	Marion Islands	Mouse, cat	Bester et al. 2002; Dilley et al. 2016
<i>Phalacrocorax africanus</i>	African Reed Cormorant	Phalacrocoracidae	LC	P*	Mascarenes, +1710	Rat, feral cat, pigs	Cheke 2013
<i>Phalacrocorax nigrogularis</i>	Socotra Cormorant	Phalacrocoracidae	E, VU	P*	Socotra	Cat	Muzaffat & Benjamin 2013
<i>Diomedea exulans</i>	Wandering Albatross	Diomedidae	VU	P**	Marion Islands	Mouse, cat	Bester et al. 2002; Dilley et al. 2016
<i>Thalassarche chrysostoma</i>	Grey-headed Albatross	Diomedidae	NE	P**	Marion Islands	Mouse, cat	Bester et al. 2002; Dilley et al. 2016
<i>Thalassarche carteri</i>	Indian Yellow-nosed Albatross	Diomedidae	EN	P**	Marion Islands	Mouse, cat	Bester et al. 2002; Dilley et al. 2016
<i>Phoebastria fusca</i>	Sooty Albatross	Diomedidae	NE, EN	P**	Marion Islands	Mouse, cat	Bester et al. 2002; Dilley et al. 2016
<i>Phoebastria palpebrata</i>	Light-mantled Albatross	Diomedidae	NT	P**	Marion Islands	Mouse, cat	Ryan 2015; Dilley et al. 2016
<i>Gygis alba</i>	White Tern	Laridae	LC	P**	Tromelin Is.	Rat	Le Corre et al. (2015)
<i>Larus dominicanus</i>	Kelp Gull	Laridae	LC	P*	Marion Islands	Mouse, cat	Bester et al. 2002; Dilley et al. 2016
<i>Stercorarius antarcticus</i>	Brown Skua	Laridae	LC	P*	Marion Islands	Mouse, cat	Bester et al. 2002; Dilley et al. 2016
<i>Aptenodytes patagonicus</i>	King Penguin	Spheniscidae	LC	P*	Marion Islands	Mouse, cat	Bester et al. 2002; Dilley et al. 2016
<i>Eudyptes chrysolophus</i>	Macaroni Penguin	Spheniscidae	LC	P*	Marion Islands	Mouse, cat	Bester et al. 2002; Dilley et al. 2016

<i>Alopochen mauritiana</i>	Mauritius Sheldgoose	Anatidae	E, EX c.1695	P*	Mauritius	Rat, <u>feral cat</u> , pig	Cheke 2013
<i>Alopochen kervazori</i>	Reunion Sheldgoose	Anatidae	E, EX c.1700	P**	Reunion	Rat, <u>feral cat</u> , pig	Cheke 2013
<i>Anas theodori</i>	Mascarene Teal	Anatidae	E, EX c.1700	P**	Mauritius	Rat, <u>feral cat</u> , pig	Cheke 2013
<i>Threskiornis solitarius</i>	Reunion Ibis	Threskiorni- thidae	E, EX 1761	P**	Reunion	Rat, <u>feral cat</u> , pig	Cheke 2013
<i>Bostrychia bocagei</i>	São Tomé Ibis	Threskiorni- thidae	E, CR	P*	São Tomé Is.	Cat, Least Weasel, rat	Hugulay et al. 2014
<i>Nycticorax mauritianus</i>	Mauritius Night Heron	Ardeidae	E, EX 1693	P**	Reunion	Rat, <u>feral cat</u> , pig	Cheke 2013
<i>Nicticorax megacephalus</i>	Rodrigues Night Heron	Ardeidae	E, EX 1726	P**	Rodrigues	Rat, feral cat	Cheke 2013
<i>Pelecanus rufescens</i>	Pink-backed Pelican	Pelecanidae	LC	P*	Madagascar +1960's	Ras, cat?	Goodman 2022
<i>Aphanopteryx bonasia</i>	Mauritius Reed Rail	Rallidae	E, EX c.1695	P*	Mauritius	Monkey, pig, rat	Cheke 2013
<i>Dryolimnas augusti</i>	Reunion Rail	Rallidae	E, EX 1675- 1705	P*	Reunion	Rat, feral cat, pig	Cheke 2013
<i>Dryolimnas cuveri abboti</i>	Assumption White-thr. Rail	Rallidae	E, EX 1908	P**	Seychelles: Assumption Isl.	Rats	Hume 2017
<i>Erythromachus leguati</i>	Rodrigues Rail	Rallidae	E, EX c.1726	P*	Rodrigues	Rat, feral cat, pig	Cheke 2013
<i>Porphyrio caerulescens</i>	Reunion Blue Gallinule	Rallidae	E, EX c.1720	P*	Reunion	Cat, rat	Cheke 2013
<i>Porphyrio sp.</i>	Seychelles Swamphen	Rallidae	E, EX c.1730	P*	Reunion	Cat	Hume 2017
<i>Fulica newtoni</i>	Mascarene Coot	Rallidae	E, EX 1693	P*	Mauritius, Reunion	Rat, pig, cat	Cheke 2013
<i>Raphus cucullatus</i>	Dodo	Columbidae	E, EX 1640's	P, H*	Mauritius	Black Rat, pig, goat	Cheke 2013
<i>Peziphaps solitarius</i>	Rodrigue's Solitaire	Columbidae	E, EX c.1770	P*	Mascarenes	Cats	Cheke 2013
<i>Columba thiriouxi</i>	Mauritius Wood Pigeon	Columbidae	E, EX	P*	Mauritius	Black Rat	Cheke 2013
<i>Nesoenas duboisi</i>	Reunion Pink Pigeon	Columbidae	E, EX c.1700	P**	Rodrigues	Cat	Cheke 2013

<i>Nesoenas rodericana</i>	Rodrigues Turtle Dove	Columbidae	E, EX 1726-1761	P**	Rodrigues	Rat, cat	Cheke 2013
<i>Nesoenas cicur</i>	Mauritius Turtle Dove	Columbidae	E, EX c.1730	P**	Mauritius	Rat, cat	Cheke 2013
<i>Nesoenas mayeri</i>	Pink Pigeon	Columbidae	E, VU	P**	Mauritius: Ile aux Aigrettes	Rat, cat, mongoose	Cheke and Hume (2008)
<i>Alectroenas nitidissima</i>	Mauritius Blue Pigeon	Columbidae	E, EX 1826	P*	Mauritius	Cats?	Cheke 2013
<i>Alectroenas payandeei</i>	Rodrigues Blue Pigeon	Columbidae	E, EX <1691	P*	Rodrigues	Rats?	Cheke 2013
<i>Mascarinus mascarinus</i>	Mascarene Parrot	Psittaculidae	E, EX 1784	P**	Reunion	Rats, cat	Cheke 2013
<i>Necropsittacus rodericanus</i>	Rodrigues Parrot	Psittaculidae	E, EX c.1770	P**	Rodrigues	Rat, cat	Cheke 2013
<i>Lophopsittacus mauritianus</i>	Broad-billed Parrot	Psittaculidae	E, EX 1670's?	P*	Mauritius	Monkey, rat	Cheke 2013
<i>Psittacula echo</i>	Echo Parakeet	Psittaculidae	E, VU	P**	Mauritius: Mauritius	Rat, cat, mongoose	Cheke and Hume (2008)
<i>Psittacula exsul</i>	Newton's Parakeet	Psittaculidae	E, EX 1875	P**	Rodrigues	Rat, cat, mongoose?	Hume 2017
<i>Otus suazieri</i>	Mauritius Scops Owl	Strigidae	E, EX 1837	P*	Mauritius	Rat	Cheke 2013
<i>Otus grucheti</i>	Reunion Scops Owl	Strigidae	E, EX 1700's	P*	Reunion	Cat and rat	Cheke 2013
<i>Otus murivorus</i>	Rodrigues Scops Owl	Strigidae	E, EX 1726-1761	P*	Rodrigues	Rat	Cheke 2013
<i>Otus pauliani</i>	Grande Comore Scops Owl	Strigidae	E, EN	P**	Comoros	Rat	Birdlife Datazone
<i>Otus moheliensis</i>	Moheli Scops Owl	Strigidae	E, EN	P*	Comoros	Black Rat?	Animalia.bio.comoros
<i>Falco punctatus</i>	Mauritius Kestrel	Falconidae	E, EN	P**	Mauritius: Mauritius	Rat, cat, mongoose	Cheke and Hume (2008)
<i>Circus maillardi</i>	Reunion Harrier	Accipitridae	E, EN	P*	Reunion, Mauritius+1606	Rat, cat, mongoose?	Goodman 2022
<i>Aepyornis maximus</i>	Elephant Bird	Aepyornithidae	E, EX 1100-700 BP	P*	Madagascar	Dog	Hansford & Turvey 2018

<i>Aepyornis hildebrandti</i>	Hildebrand's Elephant Bird	Aepyorni-thidae	E, EX 1040-1380 AD	P*	Madagascar	Dog	Hansford & Turvey 2018
<i>Mullerornis modestus</i>	Elephant Bird	Aepyorni-thidae	E, EX 680-880 AD	P*	Madagascar	Dog	Hansford & Turvey 2018
MAMMALIA							
<i>Gymnuromys robertsi</i>	Voalavoanala	Nesomyidae	E, LC	C*	Madagascar	Black Rat?	Lehtonen 2013 Goodman 1995
<i>Nesomys audeberti</i>	White-bellied Nesomys	Nesomyidae	E, LC	C*	Madagascar	Black Rat?	Miljutin & Lehtonen 2008
<i>Nesomys rufus</i>	Island Mouse	Nesomyidae	E, LC	C*	Madagascar	Black Rat?	Miljutin & Lehtonen 2008
<i>Eliurus tanala</i>	Tanala Tufted-tailed Rat	Nesomyidae	E, LC	C*	Madagascar	Black Rat?	Miljutin & Lehtonen 2008
<i>Eliurub webbi</i>	Webbie's Tufted-tailed Rat	Nesomyidae	E, LC	C*	Madagascar	Black Rat?	Miljutin & Lehtonen 2008
<i>Pachylemur insignis</i>	Giant Lemur	Lemuridae	E, EX c.1500	P*	Madagascar	Dog	Godfrey & Jungers 2003
<i>Eulemur fulvus</i>	Common Brown Lemur	Lemuridae	E, VU	P*	Madagascar Mayotte (introd.)	Dog	Hixon et al. 2021
<i>Propithecus verreauxi</i>	Verreaux's Sifaka	Indridae	E, CR	P*	Madagascar	Dog	Hixon et al. 2021
<i>Archaeolemur majori</i>	Baboon Lemur	Archaeolemuridae	E, EX 1100-700 BP	P*	Madagascar	Dog	Hixon et al. 2021
<i>Archeolemur edwardsi</i>	Monkey Lemur	Archaeolemuridae	E, EX, 500 BP	P*	Madagascar	Dog)	Godfrey et al. 2009
<i>Hadropithecus stenognathus</i>	Monkey Lemur	Archaeolemuridae	E, EX 444-772	P, H **	Madagascar	Feral cattle, pig and dog	Godfrey et al. 2009
<i>Megaladapsis madagascariens.</i>	Koala Lemur	Megaladapidae	E, EX 500-600BP	P*	Madagascar	Dog?	Godfrey et al. 2009
<i>Megaladapsis grandidieri</i>	Koala Lemur	Megaladapidae	E, EX 500-600 BP	P*	Madagascar	Dog?	Godfrey et al. 2009
<i>Megaladapsis edwardsi</i>	Koala Lemur	Megaladapidae	E, EX 500-600 BP	P*	Madagascar	Dog?	Godfrey et al. 2009

<i>Palaeopropithecus ingens</i>	Sloth Lemur	Palaeopropithecidae	E, EX 1100-700 BP	P*	Madagascar	Dog	Hixon et al. 2021
<i>Mesopropithecus pithecoides</i>	Sloth Lemur	Palaeopropithecidae	E, EX 570-679 CE	P*	Madagascar	Dog	Godfrey et al. 2009
<i>Mesopropithecus globiceps</i>	Sloth Lemur	Palaeopropithecidae	E, EX 570-679 CE	P*	Madagascar	Dog	Godfrey et al. 2009
<i>Mesopropithecus dolichobrachion</i>	Sloth Lemur	Palaeopropithecidae	E, EX 570-679 CE	P*	Madagascar	Dog	Godfrey et al. 2009
<i>Babakotia radofilai</i>	Sloth Lemur	Palaeopropithecidae	E, EX c.1000 BC	P*	Madagascar	Dog	Hixon et al. 2021
<i>Daubentonia robusta</i>	Giant Aye-aye	Daubentonidae	E, EX 900-1150 CE	P*	Madagascar	Dog)	Crowley 2010
<i>Daubentonia madagascarensis</i>	Aye-aye	Daubentoniidae	E, EN	P*	Madagascar	Black Rat?	Goodman 1995
<i>Cryptoprocta ferax</i>	Fossa	Eupleridae	E, VU	P, C*	Madagascar	Dog	Hixon et al. 2021
<i>Felis silvestris lybica</i>	African Wild Cat	Felidae	LC	P*	Namibia, Botswana, SA	Feral Cat	Measey et al. 2020
<i>Equus zebra</i>	Mountain Zebra	Equidae	VU	H*	SA, N Cape; Namibia	Feral Donkey	Measey et al. 2020
<i>Equus quagga quagga</i>	Quagga	Equidae	EX, c.1878	G*	SA, Cape, Free State	Feral donkey?	Nowak 1999
<i>Equus africanus africanus</i>	Nubian wild ass	Equidae	EX	C**	Ethiopia/Eritrea: Nubian Desert	Feral Donkey	Kimura et al. 2011
<i>Hippopotamus laloumena</i>	Malagasy Hippo	Hippopotamidae	E, EX 1670-1950 AD	P, H*	Madagascar	Dog, feral goat	Crowley et al. 1996; Shackelton 2021
<i>Hippopotamus lemerlei</i>	Lemerle's Dwarf Hippopotamus	Hippopotamidae	E, EX 670-836 AD	P, H*	Madagascar	Dog, feral goat?	Crowley et al. 1996; Shackelton 2021
<i>Hippopotamus madagascariensis</i>	Madagascar Dwarf Hippopotamus	Hippopotamidae	E, EX 687-880 CE	P, H*	Madagascar	Dog, feral goat?	Crowley et al. 1996; Shackelton 2021

<i>Hippotragus leucophaeus</i>	Bluebuck	Bovidae	EX c.1800	H*	South Africa: Western Cape	Feral goat, deer	Faith 2014
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Effects: H – habitat destruction, P – predation, C – competition, G – hybridization; *** - the only cause, ** - additional main cause, * - additional minor cause. RDB: EX - extinct, CR – critically endangered, EN – endangered, VU – vulnerable, NT near-threatened. Endemicity: E – endemic, NE – near-endemic. Alien mammals: in bracket – additional, but often ultimate/final cause of extinction.

In continental Africa, only seven vertebrate species were negatively affected by alien mammals, including 3 extinct species (Bluebuck, Quagga Zebra and African Ass). All the others affected vertebrates occur on islands. However, while islands of the Atlantic Ocean witnessed only one extinction (Cape Verde), all the others died out on islands of the Indian Ocean. Especially high rate of extinction caused by alien mammals was recorded in the Mascarenes, mainly birds (35 species), few mammals (n = 7) and no amphibian and fish species. For the contrast, only 4 species (3 birds and one reptile) became extinct in Seychelles. It is probably because the Mascarens have been occupied and transformed by man much earlier than Seychelles. In Madagascar most extinct species were among mammals (n = 16), with three bird and one reptile species.

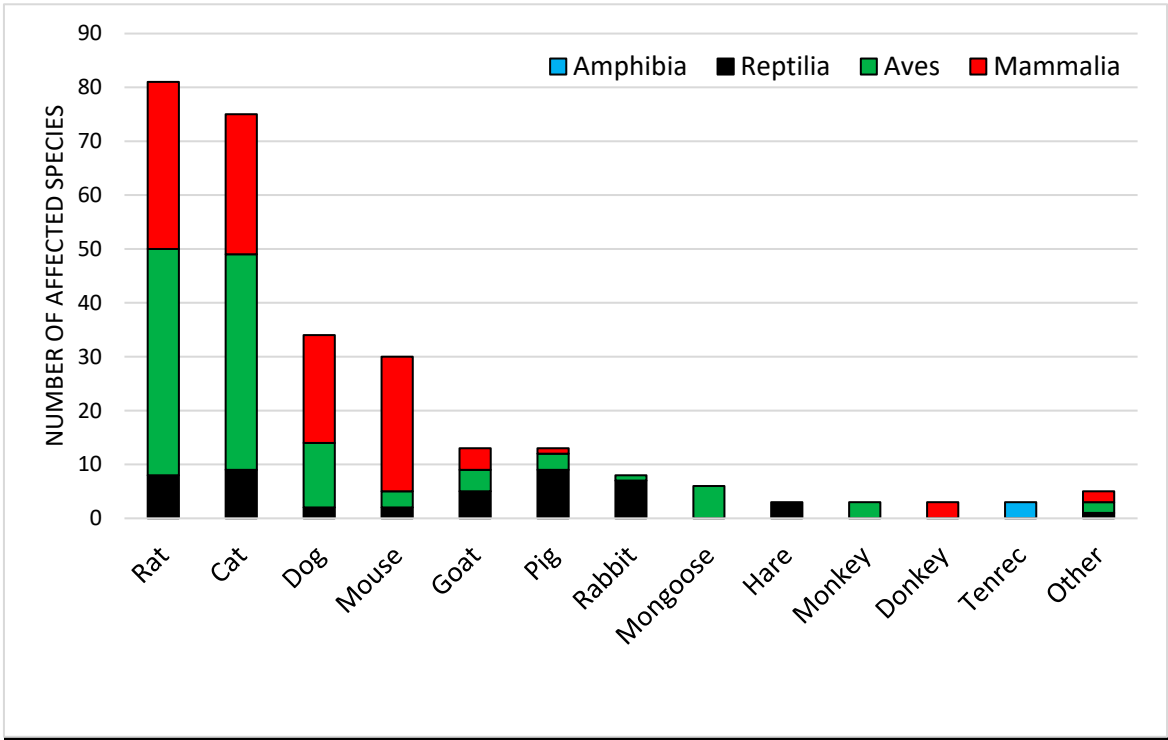


Figure 3. Number of vertebrate species affected negatively by alien mammal species in sub-Saharan Africa. .

Table 4. Familiar affinities of threatened species. Ex – extinct, En – threatened (in RDB), O – declining, rare etc., but not in RDB.

Taxa	Ex	En	O	Total	
	n	n	n	n	%
PISCES	0	0	0	3	2.1
Sooglossidae	3	0	0	3	0.0
AMPHIBIA	0	3	0	3	2.1
REPTILIA	10	9	4	23	16.0
Bolyeriidae	1	0	0	1	0.7
Typhlopidae	1	0	0	1	0.7
Scincidae	4	3	4	11	7.6
Gekkonidae	0	3	0	3	2.1
Phyllodactylidae	0	1	0	1	0.7
Testudinidae	4	2	0	6	4.2
AVES	37	31	21	89	61.8
Aepyornithidae	3	0	0	3	2.1
Phaethontidae	0	0	2	2	1.4
Sulidae	0	0	2	2	1.4
Hydrobatidae	0	1	0	1	0.7
Procellariidae	0	3	6	9	6.3
Phalacrocoracidae	1	2	0	3	2.1
Diomedidae	0	5	0	5	3.5
Laridae	0	0	3	3	2.1
Spheniscidae	0	0	2	2	1.4
Anatidae	3	0	0	3	2.1
Threskiornithidae	1	1	0	2	1.4
Ardeidae	2	0	0	2	1.4
Pelecanidae	0	1	0	1	0.7
Rallidae	7	1	0	8	5.6
Columbidae	8	1	0	9	6.3
Psittaculidae	4	1	0	5	3.5
Strigidae	3	2	0	5	3.5
Falconidae	0	1	0	1	0.7
Accipitridae	0	1	0	1	0.7
Hirundinidae	0	1	0	1	0.7
Monarchidae	0	1	0	1	0.7
Muscicapidae	0	2	0	2	1.4
Campephagidae	0	1	0	1	0.7
Zosteropidae	1	2	0	3	2.1
Acrocephalidae	1	1	0	2	1.4
Ploceidae	1	2	0	3	2.1
Sturnidae	1	0	1	2	1.4
Nectariniidae	0	0	1	1	0.7
Pycnonotidae	1	0	0	1	0.7
Cisticolidae	0	0	2	2	1.4
Passeridae	0	0	1	1	0.7
Emberizidae	0	1	0	1	0.7
Fringillidae	0	0	1	1	0.7
MAMMALIA	18	5	6	29	20.1
Nesomyidae	0	0	5	5	3.5
Lemuridae	1	1	0	2	1.4

Indrididae	0	1	0	1	0.7
Archeolemuridae	3	0	0	3	2.1
Megaladapidae	3	0	0	3	2.1
Palaeopropithecidae	5	0	0	5	3.5
Daubentonidae	1	1	0	2	1.4
Eupleridae	0	1	0	1	0.7
Felidae	0	0	1	1	0.7
Equidae	1	1	0	2	1.4
Hipopotamidae	3	0	0	3	2.1
Bovidae	1	0	0	1	0.7
Total # species	65	45	31	144	100.0

Table 5. Geographical distribution of the impacts. Ex – extinct, En – threatened (in RDB), O – declining, rare etc., but not in RDB.

Places	Reptilia			Aves			Mammalia			Total		
	Ex	En	O	Ex	En	O	Ex	En	O	Ex	En	O
AFRICA: continent	1	1	0	0	1	0	3	1	1	3	3	1
Ethiopia/Eritrea	0	0	0	0	0	0	1	0	0	1	0	0
Southern Africa	0	0	0	0	0	0	0	1	1	0	1	1
South Africa	0	1	0	0	1	0	2	0	0	2	2	0
AFRICA: islands	9	10	2	42	29	24	16	4	5	68	43	32
Cape Verde	1	1	0	0	3	5	0	0	0	1	4	5
Gulf of Guinea islands	0	0	0	0	1	0	0	0	0	0	1	0
Marion Isl.	0	0	0	0	6	4	0	0	0	0	6	4
Madagascar	1	0	0	3	1	0	16	4	5	20	5	5
Mauritius	3	9	0	11	7	2	0	0	0	14	16	2
Reunion	2	0	0	12	1	2	0	0	0	14	1	2
Rodrigues	2	0	0	12	1	0	0	0	0	14	1	1
Other Mascarenes	0	0	0	1	1	1	0	0	0	1	1	1
Comoros	0	0	1	0	3	0	0	0	0	0	3	1
Seychelles	1	0	0	3	5	3	0	0	0	4	5	3
Socotra	0	0	1	0	1	7	0	0	0	0	1	8
Total	10	11	2	42	30	24	19	5	6	71	46	33

6. Impact of Alien Mammals in Islands

6.1. Cape Verde

The archipelago Cape Verde (4033 km², 538 thousands people) is a part of larger archipelago Macaronesia, which includes also the Canary Islands, Madeira and Azores. Cape Verde is an independent state which encompass 10 islands and 16 small islands. The vertebrate fauna includes 130 bird species (incl. 40 breeding), only 3 mammal species (all bats) and 15 reptiles (incl. 12 endemics) (https://en.wikipedia.org/wiki/Wildlife_of_Cape_Verde). There is only one, in addition invasive, fish species the Guppy *Poecilia reticulata* (Lucek & Lemoine 2012).

Islands worldwide have suffered seabird extinctions after the arrival of humans and the alien species they introduced. On Santa Luzia, an uninhabited island of 35 km², the following maine bird species were extirpated: White-faced Storm Petrel *Pelagodroma marina eadesorum*, Boyd’s Shearwater

Puffinus lherminieri boydi, Cape Verde Storm Petrel *Hydrobates jabejabe*, Cape Verde Shearwater *Calonectris edwardsii*. The recent extinction of these species on Santa Luzia might be consequent on the arrival of humans and their domestic animals (mainly cats) on the island (Alho et al. 2022).

Currently, the breeding seabird community in Cabo Verde is composed of Bulwer's Petrel *Bulweria bulwerii*, White-faced Storm-petrel *Pelagodroma marina aedesorum*, Cape Verde Shearwater *Calonectris edwardsii*, Cape Verde Storm-petrel, Cape Verde Petrel, Boyd's Shearwater *Puffinus lherminieri boydi*, Brown Booby *Sula leucogaster*, and Red-billed Tropicbird *Phaethon aethereus*. One breeding species is currently extinct, the Magnificent Frigatebird *Fregata magnificens* (Semego et al. 2021). Cape Verde petrel is currently considered near threatened, and cats are the main problem (Miltao et al. 2017).

6.2. São Tomé e Príncipe and Other Islands in the Gulf of Guinea

There are four islands in the Gulf of Guinea in the Atlantic Ocean, south-west of Cameroon: two islands forming an independent state: São Tomé (854 km², 193 thousands people in 2018) and Príncipe (136 km², 5000 people in 2017), and two islands belonging to Equatorial Guinea: Bioko and (2017 km², 335 thousands people in 2015) and Annabon (17 km², 5,323 people in 2013). Most of the islands were not inhabited before the Portuguese conquest in 1493, while Bioko was occupied by Bantu people in 7th century.

The vertebrate fauna is composed of 143 bird species (incl. 23 endemics), 15 mammals (including 7 endemics), 14 reptiles (all endemics), 9 amphibians (all endemics), and 6 fish species (including one introduced, the Nile Tilapia *Oreochromis niloticus niloticus*).

This International Action Plan is designed for the conservation of the three Critically Endangered bird species, endemic to the island of São Tomé: the Dwarf Olive Ibis *Bostrychia bocagei*, the São Tomé Fiscal *Lanius newtoni* and the São Tomé Grosbeak *Neospiza concolor* (Hugulay 2014).

Predation of adults, juveniles and nests by introduced mammal species could be a potential threat for all the three species and in particular for the ibis, although there are no recorded predation events. Introduced Black Rat, Mona Monkey *Cercopithecus mona*, African Civet, cats and Least Weasel are all potential predators. Rats and the African Civets have both colonized primary forest or certainly the edges of it and are very likely to have had a deleterious effect upon nesting birds. However civets and weasels have been observed to prefer plantations. (Peet & Atkinson et al., 1994; Dutton, 1994).

6.3. Madagascar

It is the fourth largest island of the world (592,796 km²), with a population of 32 million in 2024. The island has been permanently colonized by Austronesians about 2000 years ago. It is a megadiverse country with about 90% of endemic fauna: 241 mammal species (99% endemics), 280 bird species (including 200 breeding spp., and c. 100 endemics), 280 reptile species (>90% endemics), 290 amphibian species (99% endemics) and 150 freshwater fish species (99% endemics) (https://en.wikipedia.org/wiki/Fauna_of_Madagascar).

By 600 AD, they began clearing the forests of the central highlands. About 1000 years ago they were joined by Batu people from eastern Africa, who brought zebu *Bos taurus indicus* and Sanga *Bos taurus africanus* cattle, and dogs *Canis familiaris*. The extinction event that wiped out much of the endemic megafauna on Madagascar, such as the two elephant birds, Giant Fossa *Cryptoprocta spelea*, and 17 species of giant lemurs and three hippopotamuses, followed the arrival of humans to Madagascar around 2000 years ago and dogs about 1000 years ago (Crowley 2010; Hansford & Turney 2018).

6.4. Mascarenes

An archipelago of an independent states – Mauritius (2040 km², and 1.2 million people in 2020; including Rodrigues: 108 km², Agalega: 24 km² and St. Brandon: 1.3 km²) and few French dependencies, including Reunion (2511km², settled in 17th century), Mayotte (374 km²; 257 thousand

people in 2020). The dependencies include also uninhabited four small coral islands, named Iles esparses (Dispersed Islands) in Mozambique Chanel (Europa: 28 km², Glorieuses: 7 km², Juan de Nova: 5 km² and Bassa da India: atoll 0.2 km²) and Tormeli Island (0.8 km²) east of Madagascar. They constitute a part of French Southern and Antarctic Territories.

Mascarenes fauna is threatened since 17th century, when human started to settle on the islands and transforming forests into cultivated fields and pastures. The domestic mammal species, such as cats, pigs, and also rats, monkeys and vervets further accelerated erosion of the local biodiversity. Especially severely were impacted Mauritius and Reunion. In Mauritius, 18 species became extinct in the course of 17th-20th centuries. In various islands of Mauritius, Rodrigues, Mayotte, and Seychelles, there were in 1990-2010, successful eradication of alien mammals, such as feral goat, rats, cats, Common Tenrec and House Mouse (Cheke 2013, Cheke & Hume 2008, Hume 2017).

6.5. Comoros

An archipelago (and independent state) of three islands, with a total surface are of 2,235km². It was settled by Austronesian people at 9th century, and latter also by Arab, and Bantus people. There are 15 threatened bird species and 2 species of terrestrial mammals, viz. Common Brown Lemur *Eulemur fulvus* and Mongoose Lemur *Eulemur mongoz* (although it is here in the category 'vulnerable' it is an alien species, introduced to Comoros from Madagascar). Among birds two *Otus* owl species and Humboldt's Flycatcher *Humboldia flavirostris* are threatened by rats. The Comorian Skink *Trachylepis comorensis* is threatened by feral dogs.

6.6. Seychelles

An archipelago (and independent state) of 155 small islands, with a total surface area of only 457 km² (the biggest: Mahe: 157 km², Praslin: 39 km² and La Digue: 10 km²) and population of 100,600 in 2022. Permanent settlements in the islands began with Portuguese colonization as late as in the 1770's. The vertebrate fauna includes 285 bird species (11 extinct or extirpated, 14 endemic, 16 globally endangered), only 9 terrestrial mammals (6 species of bats and 3 introduced spp.), 14 amphibian (13 endemic) and 20 lizard (>3 endemic) and 3 snake (2 endemic) species (<https://en.wikipedia.org>). Rats and cats threaten several endemic species in Seychelles, namely: Seychelles Black Paradise Flycatcher *Terpsiphone corvina*, Seychelles Magpie Robin *Copsychus sechellarum*, Seychelles White-eye *Zosterops modestus*, Seychelles Warbler *Acrocephalus sechellensis*, Seychelles Fody *Foudia sechellarum*, Wedged-tailed Shearwater *Ardenna pacifica*, White-tailed Tropicbird *Phaethon lepturus*, Masked Booby *Sula dactylatra* (Rocamora and Henriette 2015). Six bird species extinct in Seychelles, e.g. Marianne white-eye, Seychelles parakeet, Aldabra brush warbler. In addition, the saltwater crocodile, most of the giant tortoises from the 40 granitic islands. However, the number of extinct species was by far much lower than in Mauritius, partly due to a shorter period of human occupation

6.7. Socotra

After Madagascar, it is the second largest African island, with a surface are of 3625 km² and c. 60 thousands people. It is situated in the Gulf of Aden between the Horn of Africa and Arabian Peninsula. No latter than 2,000 years ago, the island was permanently settled by Arab and Indian people. Today it is administered by Yemen. Socotra is a home to 180 species of birds (41 breeding, and 10 endemic), 14 species of mammals, including domesticated species and the only indigenous mammals – bats, and 22 reptile species (including 19 endemic) (<https://www.welcometosocotra.com/fauna-and-flora>). Some vertebrate species are negatively affected by habitat destructed by feral mammals. One of the reptile species, *Trachylepis socotrana*, is threatened by invasive species (Damme & Banfield 2011).

6.8. Prince Edward Islands

These two uninhabited sub-Antarctic volcanic islands, Marion (279 km²) and Prince Edward (46 km²), harbor a wealth of sub-Antarctic seabirds and marine mammals. Both islands are administered by South Africa. The islands constitute breeding grounds of millions of seabirds from 29 species: four penguins, five albatrosses, two giant petrels, seven petrels, two prions, two diving-petrels, at least two storm-petrels, two terns and Brown Skua, Kelp Gull and Crozet Shag (Bester et al. 2002, Ryan 2015, Dilley et al. 2016). About 800,000 pairs King and Macaroni Penguins nest in colonies on the islands (William et al. 1979). The most abundant birds on the islands are burrow-nesting petrels. Numbers of burrowing petrels were greatly reduced by cats that roamed Marion Island from 1948 to 1991. The density of burrows on Marion Island is much lower than on the neighbouring Prince Edward Island, where there are no introduced mammals. The eradication of cats led to some recovery in petrel numbers, but this has been slower than expected due to predation by mice, introduced to the islands before the cats (Greve & Meden 2020).

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