



# The species diversity, distribution and conservation of Namibian mammals

MICHAEL GRIFFIN

*Biodiversity Inventory, Ministry of Environment and Tourism, Private Bag 13306, Windhoek, Namibia*

Namibia's extant mammal fauna of 250 species represents about 75% of the southern African region's species richness, 83% of generic richness and 98% of familial richness. Fourteen species are presently recognized as endemic (75% or more of the global population occurring within Namibian borders). These endemics occur in the Namib Desert, pro-Namib transition zone and adjoining escarpment, and are primarily rupicolous. The Namibian endemic mammal fauna is characterized by the monotypic Petromuridae, and the rodent genera *Gerbillurus* and *Petromyscus*. The distribution of smaller species has probably not changed significantly over the past 200 years, but species such as lion and plain zebra have undergone range reductions of 95% or more, and five species are listed as recently extinct. Approximately 50% of all Namibian mammal species are provisionally listed as 'secure'. However, due to patchy data, 94 species (38%) are classified as under possible or probable threat. Nineteen species (8%) are classified as under definite threat. Over 13% of Namibia is set aside by the state for conservation purposes. Ninety-five percent of mammal species occur in at least one park, over 80% occur in three or more parks, and 59 species (28%) occur in ten or more parks, although for most species nothing is known of their population viability there. Major threats to mammals in Namibia are invasive aliens, including the risk of genetic pollution, and habitat alteration, especially wetland degradation.

*Keywords:* mammalian richness; endemism; Namibia, arid-zone biogeography.

## Introduction

Namibian mammals, originating as part of the Gondwana fauna, have been present for at least 20 million years (Stromer, 1926). Man's relationships with other mammals as an active member of the Namibian mammal community date back to at least 300 000 BP and presumably much earlier (Corvinus, 1983). The earliest southern African Miocene hominoid, *Otavipithecus namibensis*, dated to 12–13 million years, is known from the Otavi highlands of northern Namibia (Conroy *et al.*, 1992), but the only evidence attesting to these early relationships is via fossils, Acheulian artifacts, kitchen middens, and stone art. It was not until the late 1400s that Portuguese explorers visited the region now known as Namibia. The subsequent settlement of the Cape Province in South Africa by European colonists began the next phase of southern African mammalogy, that of the systematic collection and classification of species. From the Cape Colony, explorers of the 18th and 19th centuries such as Pieter de Bruin and Jacobus Coetzee visited southern Namibia in the mid-1700s, but left no written records of their observations (Skead, 1980). Thus the first modern documented observation of a Namibian mammal was by Hendrik Hopp, who in October 1761 saw giraffe in the Houns River at Warmbad hot springs (Mossop, 1935). Setting the precedent for an enduring Namibian tradition, he shot one the next day. This was an era when 40% of the foreign travellers and residents were described as hunters, sportsmen, naturalists and collectors (Tabler, 1973), almost without exception interested

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in large huntable game. It is therefore surprising that the first novel mammal described from Namibia was a bat (Bechstein, 1800).

The first modern systematic survey, by Captain Guy Shortridge of the Kaffrarian Museum in the 1920s and 1930s, resulted in the two-volume *Mammals of South West Africa* (Shortridge, 1934). In this monumental work, Shortridge lists 165 terrestrial and one marine species as occurring in Namibia, with an additional 31 expected. Since then, the Namibian mammal fauna has been addressed as part of broader regional accounts (e.g. Allen, 1939; Roberts, 1951; Ellerman *et al.*, 1953; Meester and Setzer, 1971–77; Smithers and Skinner, 1983; Meester *et al.*, 1986; Skinner and Smithers, 1990).

Namibia signed the Convention on Biological Diversity in June 1992, and ratified it in March 1997. The current status of our knowledge and conservation of Namibia's biodiversity has just been assessed (Barnard, 1998), and this paper summarises information on the country's mammals (Griffin, 1997).

## Methods

Data on Namibian mammals are available from approximately 45 000 specimens at the National Museum of Namibia, Transvaal Museum, and 12 other museums with significant but lesser holdings, as well as from 1300 publications and reports (Griffin, 1997). Conservation status rankings for the majority of species are entirely provisional, as few data are available for most species. A map of expected species richness (Fig. 1) was generated by overlaying hand-drawn range maps for individual species, based on the above data sources and the results of unpublished and ongoing fieldwork.

## Results and discussion

### *Richness and endemism*

The most recent estimation of national species richness is given by Griffin and Coetzee (in press). They list 217 species known and a further 33 species expected to occur in Namibia. This estimation includes the order Cetacea, a group not considered by Shortridge (1934). These taxa represent 75% of regional species richness, 83% of generic richness and 98% of familial richness, where the southern African region is defined as that area south of the Kunene and Zambezi Rivers. Namibia, at 823 988 km<sup>2</sup>, makes up roughly 25% of this area. Table 1 places the richness of the extant Namibian mammal fauna in regional, continental African, and global perspective.

Except where noted, Namibian endemic mammals are defined in this paper as those species with  $\geq 75\%$  of their population within Namibia. This is meaningful in biogeographic terms, as many bioregional endemics occur marginally in adjacent provinces of neighbouring countries such as Angola (Simmons *et al.*, 1998). It is also aimed at securing maximum local protection, since neighbouring countries with marginal populations of these endemics are unlikely to give them priority. Table 2 places the endemism of Namibian mammals in regional and continental perspective. Fourteen mammal species in Namibia are currently thought to meet the 75% criterion. Of these, 13 are bats, rodents and small carnivores (Table 3). These species are poorly understood geographically and/or taxonomically, so the confidence of these assignments is low. Griffin (1997) depicts a potential distribution array for these species. Namibia's endemic mammals are distributed along a north–south axis, generally restricted to the Namib Desert, pro-Namib transition

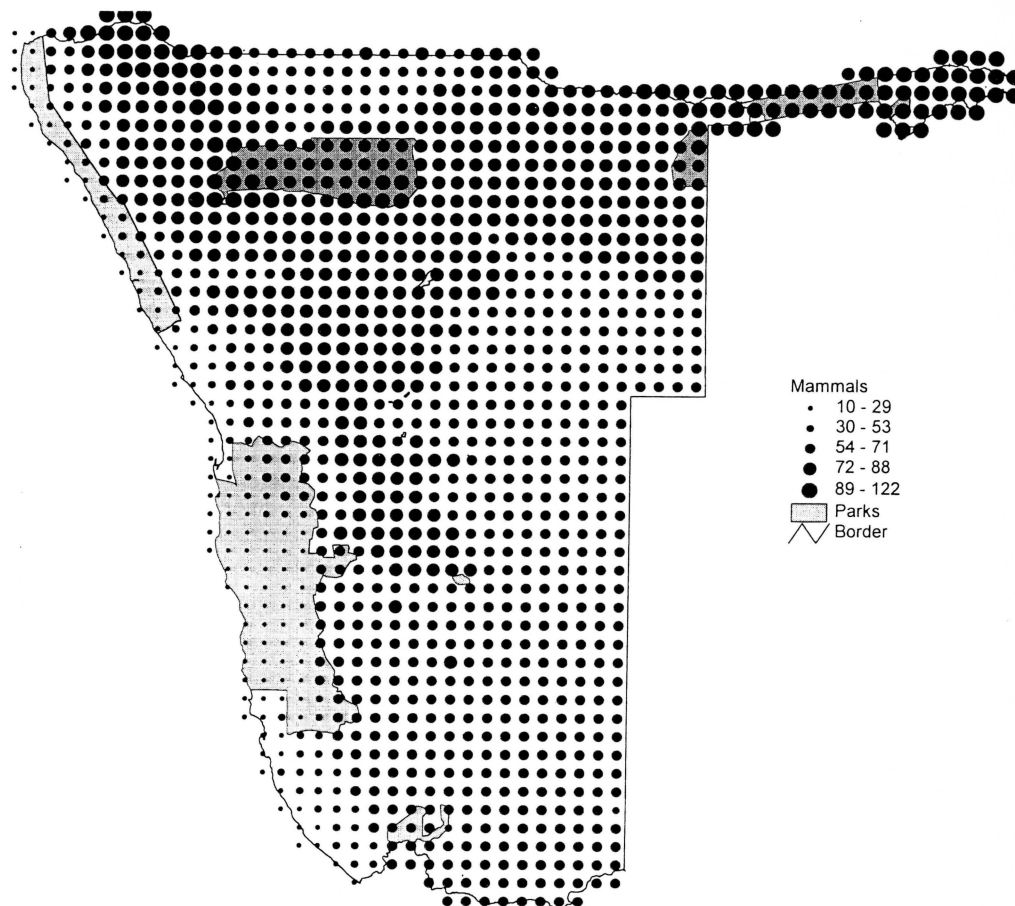


Figure 1. Expected species richness of 208 terrestrial Namibian mammals.

zone and adjoining rocky escarpment. Over 60% of these endemics are rupicolous. The endemic mammal fauna is characterized by the endemic rodent family Petromuridae (the monospecific dassie rat, *Petromus typicus*) and the rodent genera *Gerbillurus* (all four species are endemic to, or occur extensively in Namibia) and *Petromyscus* (four of the five species are endemic to, or occur extensively in Namibia). Simmons *et al.* (1998) gives an integrated analysis of Namibian endemism.

Table 1. Taxon richness of indigenous Namibian mammals in regional, African, and global context (modified from Skinner and Smithers, 1990; Cole *et al.*, 1994)

Taxon	Namibian	Southern African	African	Global
Species	250	338	1052	4629
Genera	147	178	301	1135
Families	45	46	54	136
Orders	14	15	15	26

**Table 2.** Endemism<sup>a</sup> in Namibian mammals in regional and African context (modified from Smithers and Skinner, 1990; Cole *et al.*, 1994)

Taxon	Namibian	Southern African	African
Species	1%	17%	93%
Genera	0%	7%	78%
Families	0%	0%	33%
Orders	0%	0%	3%

<sup>a</sup> This table uses the concept of strict (100%) endemism. 'Endemism' in Namibia throughout the rest of the paper is defined as 75% or more of a taxon's global population falling within the boundaries of Namibia, as many species occur marginally in adjacent countries.

**Table 3.** Provisional conservation status<sup>a</sup> of indigenous Namibian mammals: number of species per order in each conservation status category; a species may occur in more than one category

Order	Endg	Vuln	Rare	Indet	Insf	Endm	Peri	Secure
Insectivora	–	–	–	–	1	–	3	4
Chiroptera	–	–	–	2	2	2	16	28
Primates	–	–	–	–	1	–	2	2
Carnivora	1	4	4	10	4	2	17	14
Cetacea	–	–	–	6	6	–	38	1
Proboscidea	–	1	–	–	–	–	1	–
Perissodactyla	1	–	–	–	2	1	2	1
Hyracoidea	–	–	–	–	–	–	–	2
Tubulidentata	–	–	–	–	–	–	–	1
Artiodactyla	2	9	1	3	6	–	18	10
Pholidota	–	1	–	–	–	–	–	–
Rodentia	–	–	3	–	1	9	12	39
Lagomorpha	–	–	–	–	–	–	–	5
Macroscelidea	–	–	–	–	–	–	1	5
Total	4	15	8	21	23	14	110	112

<sup>a</sup> Endg = endangered; Vuln = vulnerable; Indt = indeterminate; Insf = insufficiently known; Endm = endemic; Peri = peripheral (categories as in Griffin, 1996).

### Biogeography

The Namibian mammal fauna has long been recognized as distinct. Bigalke (1972) noted the uniqueness of the Southwest Arid biogeographical region, and Rautenbach (1978) further subdivided the region into three biotic zones: Namib Desert, Southwest Arid, and Southern Savanna Woodland. Coetzee (1983) renamed these zones 'Mammalian Zoogeographical Provinces' and identified six sub-provinces composed of 11 districts. Many of these districts resemble Giess' (1971) vegetation zones (see Barnard *et al.*, 1998; R.E. Griffin, 1998 in this volume). Figure 1 illustrates the expected richness distribution of 208 species of terrestrial Namibian mammals. Coetzee (1983) earlier outlined the expected distribution of 150 terrestrial species. The overall distribution pattern illustrates a gradient from southwest to northeast, similar to that of rainfall (Barnard, 1998). Expected species richness maps for Insectivora, Carnivora, Chiroptera, Rodentia, ungulates and all other mammals of conservation concern are given in Griffin (1997).

In addition to rainfall and the historical effects of hunting and persecution, which are most evident for ungulates and large carnivores, three physiographic factors have a major influence on this distribution array. (1) The mammal fauna in the Caprivi Strip, in northeast Namibia, is influenced by corridors of suitable habitat provided for mesic northern faunas by the Okavango, Kwando, and Zambezi Rivers (Griffin and Grobler, 1991). (2) The central escarpment separates the Namib and pro-Namib fauna from that of the central plateau highlands. Coetzee (1983) recognized this as the only significant natural barrier to Namibian mammal distribution. (3) The two Namib 'sand seas', separated by nearly 300 km, limit regional diversity because of reduced habitat heterogeneity and an unsuitable substrate for many species. This influence is partially mollified, however, by inselbergs and perennial rivercourses which provide limited habitat for species otherwise non-characteristic of the area (Coetzee, 1969; Seely and Griffin, 1986; Loutit, 1991).

The similarity of some animal taxa of the Southwest Arid biogeographical zone to those of the Somali arid region has long been recognized (Coe and Skinner, 1993), although affinities of corresponding taxa in the two regions are not generally well understood. Davis (1975) recognized the distinction of southern African *Gerbillurus* from East African *Gerbillus*, and Kumamoto *et al.* (1994) provided evidence separating the two disjunct populations of Damara dik-dik *Madoqua kirkii*. Another ten Namibian mammal taxa in widespread orders show this disjunct pattern.

The Namibian marine mammal fauna is a marginal component of the broad southern Atlantic marine mammal community. It includes three species of pinnipeds and potentially 40 species of cetaceans. Little is known of the nature of occurrence of many species (Findley *et al.*, 1992). Baleen whales (families Balaenidae, Neobalaenidae and Balaeopteridae) are thought to be primarily seasonal visitors, possibly with resident populations. A number of delphinid species, in particular dusky dolphin *Lagenorhynchus obscurus*, bottlenose dolphin *Tursiops truncatus* and the Benguela dolphin *Cephalorhynchus heavisidii* are year-round residents, and two of the three species of sperm whales (Physeteridae and Kogiidae) are confirmed from Namibia. Nine species of beaked whales (Ziphiidae) occur or are expected to occur in Namibian waters, with *Mesoplodon grayi* and *M. layardi* two of the most frequently stranded. The southern bottlenose whale *Hyperoodon planifrons* has recently been recorded from the Namibian coast for the first time. Namibia is geographically well situated for occasional visitors from the warm Indian Ocean (via the Benguela and Agulhas currents), central east Atlantic (via the seasonal Angola current) and south Atlantic.

#### *Conservation status*

The distribution of smaller mammal species has changed little, if at all, during recorded history (Meester, 1973). Larger species, particularly those of economic value, have experienced major range reductions. Plains zebra *Equus burchelli* and lion *Panthera leo* are examples of species with Namibian range reductions of 95% or more over the past 200 years. Other potentially vulnerable species like springbok *Antidorcas marsupialis*, leopard *Panthera pardus* and gemsbok *Oryx gazelle* have apparently not suffered significant range reductions. Still other species, for instance greater kudu *Tragelaphus stripsiceros*, have benefited by bush encroachment and the establishment of artificial water sources (Griffin and Lensing, 1981).

As a general pattern, vulnerable mammal species receded in a northern and eastern direction, leaving the northeast region today as the only haven for many species which

originally had broad Namibian ranges (M. Lindeque, *in litt.*). This process was probably as much a function of habitat suitability and carrying capacity as to the actual progression of armed settlers. A primary entry point into Namibia for explorers and settlers was at the Orange River in the Warmbad area, which apparently had a high richness, but low populations of large mammals. By the early 1800s mammal populations in this area had been decimated (Skead, 1980) and today it holds the national record for most regional extinctions.

The conservation status of all Namibian mammals is now under review, and as an interim measure a list of species with provisional conservation status rankings has been produced (Griffin, 1996). The frequency of occurrence of species in each of eight categories is given in Table 3. Approximately 50% of all Namibian species are provisionally considered to be of conservation concern (i.e. any ranking other than just 'secure'). In practice, however, many of these 'secure' species are also of considerable economic interest, such as greater kudu, gemsbok and springbok in trophy hunting, subsistence hunting, and ecotourism. Few Namibian species have been studied sufficiently to allow the assignment of definitive conservation status categories. For example, although 19 species (8%) are assigned to definite threat categories, a further 94 species (38%) are assigned to possible or probable threat categories. Many species, if not most, would be defined as 'data deficient' using the latest red data guidelines (IUCN, 1994). This interim status confers a high level of protection until species are evaluated and confidently placed into categories. In practice, 'rare' is not by itself considered a threat category in Namibia.

#### *Threats to mammalian diversity*

Severe over-hunting of game mammals on private land in Namibia was a major threat for the first half of this century, but was successfully reversed in 1967 when legislation shifted the ownership of game from the state to the individual landowner. This allowed landowners to commercialize game mammals, rather than incur losses through perceived competition of game with stock production. The Nature Conservation Amendment Act of 1996 extends similar fundamental rights to people living in communal areas, with the hope that rural communities, realizing the values of wildlife, will also manage it sustainably. In practice, however, this concept does not always promote sound biodiversity preservation principles. When game reverted to private ownership on commercial farmlands, numerous landowners imported genetically alien mammals if local mammals were not available from the conservation authority at the time. This has led to many privately owned game populations of debatable conservation value. Today, for example, populations of roan antelope *Hippotragus equinus* on Namibian farmlands are made up of original Namibian stock mixed with animals from Zimbabwe and Malawi (see also 'Extinct and alien mammals'). It also remains unclear whether the active management of land to favour game mammal populations is always favourable to the broader interests of biodiversity protection.

Land degradation through the overuse of natural resources is a significant threat to biodiversity generally, including mammals. For example, drought is a natural phenomenon in Namibia, and the species composition of local mammal communities changes according to environmental conditions. During the above-average rainfall of the late 1970s, some small mammal species (e.g. *Tatera leucogaster*, *Saccostomus campestris* and *Mus indutus*) invaded the central Namib from east to west for distances up to 50 km. Several years later, after a series of poor rainfall years, these populations completely disappeared from the central Namib and receded back to the base of the escarpment (Griffin, 1990). Such patterns of temporal and spatial variability will continue if ecosystems are left intact, and can

only be regarded as a normal feature of arid environments. However, overgrazing and/or deforestation greatly reduces the resiliency of ecosystems, often to the extent that when rains do arrive, ecological functions and patterns have been disrupted. The result may be bush encroachment, which may lead to changes in mammalian diversity or community structure, or at the extreme end desertification, which can cause a significant loss of local mammalian diversity. While widespread bush encroachment may arguably enhance habitat for a few species such as greater kudu, Damara dik-dik, and even cheetah *Acinonyx jubatus* (Nowell, 1996), its net effects on mammalian diversity are likely to be negative.

Deforestation is a direct assault on the survival of tree-dependent species such as galagos *Galago moholi*, vervets *Chlorocebus aethiops*, tree rats *Thallomys* spp, tree squirrels *Funisciurus congicus* and many tree-roosting bats (e.g. *Scotophilus* spp, *Kerivoula* spp, *Nycteris* spp and *Epomophorus* spp). It is also a major problem in the mesic regions of Namibia, especially riverine habitats. For instance, of the 470 km of Okavango River frontage occurring in Namibia, less than 30 km remain in a fairly pristine state.

Wetlands make up less than 5% of Namibia's surface geography, and in the context of the country's arid landscapes, are under constant and severe pressure (Simmons *et al.*, 1991; Curtis *et al.*, this issue). The occurrence of water- and wetland-dependent Namibian mammals is summarized by Griffin and Grobler (1991). Nineteen species (10%) are at least seasonally dependent on free water, and a further nineteen species are dependent on or restricted to wetland habitats. As wetland habitats are generally under threat (Curtis *et al.*, this issue), all wetland-dependent species are also considered to be at risk.

#### *Extinct and alien mammals*

It is difficult to say exactly how many mammalian extinctions there have been in Namibia during recorded history, as early accounts of the occurrence and distribution of mammals were often vague and inaccurate (Meester, 1973). At least ten mammal species originally recorded (or inferred) as occurring in Namibia have not been confirmed since. Early accounts may have accurately recorded the presence of vagrant individuals, or of marginal populations already on the decline. In some cases they may have been entirely unsubstantiated speculation (e.g. Fischer, 1913). Due to insufficient data on most species, there is only high confidence about the extinction within historical times of white rhino *Ceratotherium simum*, Cape warthog *Phacochoerus aethiopicus*, quagga *Equus quagga* and yellow-winged bat *Lavia frons*. Also, the waterbuck *Kobus ellipsyprymnus* may have gone extinct within Namibia since 1990, although the species occurs in neighbouring countries immediately adjacent to the eastern Caprivi border.

Griffin and Panagis (1985) listed six feral alien and eight invasive alien mammals for Namibia. Twelve years later, only the feral domestic goat *Capra capriolus* is no longer considered invasive, but awareness of the overall problem has increased. Domestic mice *Mus musculus* have become established in at least four feral situations along the Namib Coast, and donkeys remain a major conservation problem along the lower Orange River, despite major efforts to remove them. The primary area of concern, however, is genetic pollution. The cross-breeding of *Felis domesticus* with African wild cats *F. sylvestrus* is a widespread problem. The small-spotted cat *F. nigripes* has always been considered rare in Namibia (Shortridge, 1934) and is currently listed as 'indeterminate'. There is some concern that there may be interactions between *F. sylvestrus*, *F. sylvestrus/domesticus* hybrids and *F. nigripes*, which could negatively affect the conservation status of *sylvestrus* and *nigripes* (Nowell and Jackson, 1996).

Despite clear national policy on conserving genetic integrity, the policy has not been effectively implemented. There has, for instance, long been official recognition of the genetic effects of mixing common impala *Aepyceros melampus melampus* with the endemic black-faced impala *A. m. petersi*, yet the two forms have been mixed on many commercial farms. This situation has caused consternation among both conservationists and trophy hunters dissatisfied with the taxonomic uncertainty of their trophies (Green and Rothstein, in press).

#### *Mammals and the protected area network*

Nearly 14% of Namibia is designated as formal (government) conservation areas. The network is a haphazard accumulation of parcels ranging in size from  $<1 \text{ km}^2$  to nearly  $50\,000 \text{ km}^2$  (Appendix 1 in Barnard *et al.*, this issue). Several, particularly the smaller ones, are managed primarily as public recreation facilities and only secondarily or not at all as biodiversity reserves. The first reserves, established by the German colonial administration in 1907, were meant to preserve local game species, and at the time were regarded as useless for anything else.

Table 4 summarizes the known and expected occurrence of Namibian terrestrial mammals within the protected area network. Despite the unsystematic way in which conservation areas were obtained, over 95% of Namibian terrestrial mammals are expected to occur, at least marginally, within the present protected area network. Over 80% of species occur in three or more protected areas, and 59 species (28%) occur in ten or more conservation areas. Although data on species occurrence are given with fairly high confidence, the significance of mere occurrence is unclear. Information on the long-term viability of these populations is not yet available for the majority of Namibian mammals, and the prognosis for some large species is not good. For example, black rhinos *Diceros bicornis*, of which Namibia has the largest remaining unfenced population, are being fragmented into small, disjunct populations in an urgent management attempt to control poaching (Reuter and Barnard, 1997). Assuming that poaching can be resisted, careful demographic modelling and scientific management will be needed for the recovery of Namibia's rhino population (e.g. Lacy, 1997). The wild dog *Lycaon pictus* is another red data species on the decline in Namibia, which is, perhaps inevitably, insufficiently safeguarded by the protected area network, and will need creative joint management to ensure its future (Hines, 1990).

Of major concern are habitats and species which are badly neglected by the current network. Rivers and riparian vegetation are particularly vulnerable to widespread alteration, and are poorly protected by the parks system (Curtis *et al.*, this issue). The western escarpment and adjacent mountainous plateau, where most endemics in Namibia occur (Simmons *et al.*, this issue) have adequate protection in central and southern Namibia, but not in the north where many vertebrate endemics are concentrated. The Brukkaros Crater, an evolutionary hotspot for the endemic rodent genus *Petromyscus* and other endemics, is also not included in the protected area network. Although the central Kalahari Desert is a major landscape of eastern Namibia, it is not represented in the network. Its mammal fauna show little regional specificity, however, and individual species are found in other landscapes and protected areas.

Namibian marine mammals are of national concern. They are fully protected by the Sea Fisheries Act (29 of 1992), administered by the Ministry of Fisheries and Marine Resources. Namibia also controls a 200-km exclusive economic zone, in terms of which commercial fishing practices undergo a local evaluation process. However, the rich stocks of baleen whales present in Namibian waters prior to the two collapses of the whaling



**Table 4.** Protection status of indigenous Namibian mammals: number of species in formal conservation areas (including those species expected to occur)

Order	Protected area <sup>a</sup>															Total species in Namibia	Total species in parks
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Insectivora	6	4	4	2	4	2	4	3	3	3	2	2	1	–	1	8	8
Chiroptera	36	35	28	24	22	18	14	10	10	14	13	11	12	4	16	48	43
Primates	3	3	3	3	2	1	2	1	1	1	–	1	1	–	1	4	3
Carnivora	25	27	26	23	25	26	19	14	14	21	12	16	16	11	20	38	38
Cetacea	–	–	–	–	–	+	–	–	–	+	+	–	–	+	–	40	–
Proboscidea	1	1	1	1	1	1	–	–	–	–	–	–	–	–	–	1	1
Perissodactyla	1	2	1	1	3	2	1	1	1	1	–	1	–	–	1	2	2
Hyracoidea	–	–	–	–	1	1	1	1	1	1	–	1	1	–	1	2	2
Tubulidentata	1	1	1	1	1	1	1	1	1	1	1	1	1	–	1	1	1
Artiodactyla	20	18	17	13	14	8	15	10	7	8	4	8	6	1	7	28	26
Pholidota	1	1	1	1	1	–	1	1	1	–	–	1	1	–	–	1	1
Rodentia	26	25	24	21	23	21	22	20	18	23	12	22	21	7	22	53	47
Lagomorpha	2	2	2	1	3	3	1	2	2	4	1	3	3	1	2	5	5
Macroscelidea	1	1	1	1	2	3	1	1	1	3	2	3	3	1	4	6	5
<b>Total</b>	<b>123</b>	<b>120</b>	<b>109</b>	<b>92</b>	<b>102</b>	<b>87</b>	<b>82</b>	<b>65</b>	<b>60</b>	<b>80</b>	<b>47</b>	<b>70</b>	<b>66</b>	<b>25</b>	<b>76</b>	<b>237</b>	<b>–</b>

<sup>a</sup> Protected areas: 1 Mudumu + +Mamili National Parks; 2 West Caprivi Game Park; 3 Mahango Game Reserve; 4 Khaudum Game Park; 5 Etosha National Park; 6 Skeleton Coast National Park (including Cape Cross Seal Reserve and National West Coast Recreation Area); 7 Waterberg Plateau Park; 8 Daan Viljoen Game Park; 9 Von Bach Recreation Resort; 10 Namib Naukluft National Park; 11 Walvis Bay Lagoon; 12 Hardap Recreation Resort; 13 Naute Recreation Resort; 14 National Diamond Coast Recreation Area; 15 Ai-Ais Hot Springs/Hunsberg Complex. Excludes areas of less than 1000 ha. Many populations in parks may not be viable.

industry in the early 1800s and early 1900s have not yet recovered. So, although Namibia is fully committed to the concept of sustainable harvesting of natural resources, a new whale fishery will not be established in the foreseeable future. Cape fur seals, *Arctocephalus pusillus*, of which Namibia has approximately two-thirds of the world population (J.-P. Roux, pers. comm.), are harvested regularly on an ostensibly sustainable basis. This species, plus two vagrant species from the Antarctic convergence, is well protected along the Namibian coast: approximately 1400 km of the roughly 1500-km coastline plus all offshore islands are under formal or informal protection.

From a national biodiversity preservation perspective, protected areas such as conservancies and private game reserves, particularly those adjoining formal reserves or holding species of conservation concern, can increase the viability of some populations to the point of sustainability. For instance, recent private initiatives in the region adjoining the Naute Recreation Resort and Ai-Ais/Hunsberg Complex have effectively doubled the area set aside for the preservation of local biodiversity in this region, an area of high endemism (Simmons *et al.*, this issue). Similarly, the long-term population viability of cheetah in Namibia may be entirely in the hands of sympathetic private landowners (Nowell, 1996). Market incentives, if strongly guided and controlled by a competent conservation authority, can be an invaluable tool in a coordinated national programme to preserve biodiversity. However, even private game reserves, which cater to the expectations of the ecotourist or trophy hunter and manage resources to fulfil those expectations, may neglect or unwittingly eliminate less visible components of biodiversity.

The Nature Conservation Ordinance (4 of 1975, with subsequent changes) lists ten species of 'specially protected game', comprised of nine ungulates and the elephant *Loxodonta africana*, and 21 species of 'protected game' (ten carnivores, 17 antelope, aardvark *Orycteropus afer*, Cape pangolin *Manis temminckii*, southern African hedgehog *Atelerix frontalis* and the lesser bushbaby *Galago moholi*). In addition, six ungulates are designated as huntable game, while the chacma baboon *Papio ursinus*, rock dassie *Procavia capensis*, black-backed jackal *Canis mesomelas* and caracal *Caracal caracal* are designated as 'problem animals'. All other mammal species are defined merely as 'wild animals', which have a greatly reduced protection status.

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