Distributional patterns and conservation status of mammals of Swaziland, southern Africa

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Distributional patterns (mapped at the quarter-degree square scale) of species richness of 121 species of mammals recorded from Swaziland were examined in relation to the distribution of protected areas (reserves), privately-owned ranches and six vegetation types. The richness of mammal species was highest in the NE and NW, and lowest in the SW areas of Swaziland. Total mammal species richness was positively and highly significantly correlated with the presence of reserves. Similar patterns were shown by artiodactyls, rodents and carnivores. Total mammal species richness, as well as for most mammalian orders, was positively correlated with moist grassveld and moist savanna vegetation types but negatively correlated with dry grassveld. Mammal species richness, especially for the larger species, was very low on Swazi Nation Land, which covers about 60% of the country. The mammalian fauna of the high-lying areas (Highveld) was distinct from that of the low-lying areas (Lowveld). The Middleveld region supported elements of both Highveld and Lowveld species. A large proportion (87.6 %) of Swaziland's mammal species have been recorded from reserves. Two species (*Alcelaphus lichtensteini* and *Lycaon pictus*) no longer occur in Swaziland. For effective conservation of Swaziland's mammals, the issue of how to maintain viable populations on Swazi Nation Land will have to be addressed.

Key words: Swaziland, mammals, distribution, conservation.

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Introduction

One of the steps in developing a national action plan for the conservation of biodiversity is the preparation of checklists of species present in the country and the mapping of their distributions. This allows an assessment of the number of species present or absent in protected areas, and an evaluation of priority conservation areas (Lombard 1995). One way of conserving biodiversity is the establishment of protected areas (van Jaarsveld 1995), hence the more species that occur in these areas the better the prospect that fewer species will, at least theoretically, become extinct. Prioritizing areas with conservation potential or value is becoming critically important as the pressure to exploit "pristine" areas continues to increase dramatically (Wilson 1992). Prioritization of these areas may be achieved by hotspot analysis (Lombard 1995) which can only be conducted if the distributions of the species are known.

The mammalian fauna, especially the Rodentia, Insectivora and Chiroptera of Swaziland has been poorly studied and until recently even a checklist of species did not exist. In addition, Swaziland's mammals have been poorly represented in Museum collections. An extensive survey of the mammals of Swaziland was thus undertaken between 1993 and 1996 (Monadjem 1997a; Monadjem *in press*). The objectives of this survey were to record the species of mammals occurring in Swaziland and to map their distribution patterns. To address these questions, all quarter-degree squares (QDS: 15'×15') falling within the country were

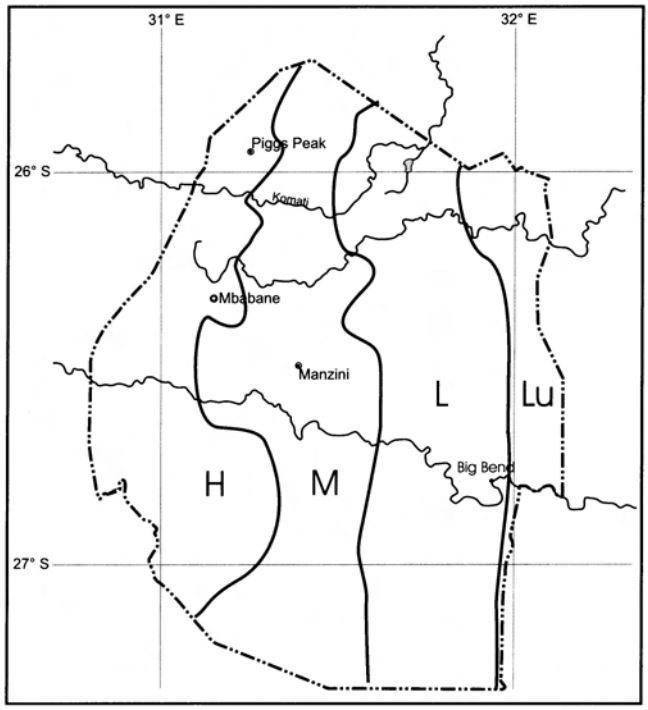


Fig. 1. Map of Swaziland showing the four geographical regions: H = Highveld region; M = Middleveld region; L = Lowveld region; and Lu = Lubombo region.

sampled. Due to the small size of Swaziland, the ascertained distribution patterns of most of the mammals within the country are considered to accurately portray their actual distributions. This degree of cover for Swaziland has not been achieved in the survey of the mammalian fauna of any other southern African country (eg. Shortridge 1934; Smithers 1971; Smithers & Tello 1976; Smithers & Wilson 1979; Ansell 1978; Rautenbach 1982; Lynch 1983; Ansell & Dowsett 1988; Lynch 1989; Lynch 1994; Gelderblom *et al.* 1995; Mugo *et al.* 1995; Rowe-Rowe & Taylor 1996).

The objective of this paper is to present the distribution patterns exhibited by the mammals of Swaziland and, which in turn is used to assess their conservation status within Swaziland.

Study area

Swaziland is a small, landlocked southern African country, covering an area of 17 565 km² (Goudie & Price-Williams 1983). Swaziland lies approximately between 25°45'S – 27°18'S and 30°08'E – 32°08'E. Despite its small size, Swaziland is topographically diverse with altitude ranging from 150 m to 1862 m above sea level (Goudie & Price-Williams 1983). Swaziland is divided into four geographical regions which run in a north-south plain (Fig. 1).

The Highveld lies in the west. The average altitude ranges from 1050 m to 1400 m a.s.l., but with some higher peaks. Mean annual temperatures are cool (16 °C) and annual rainfall high (about 1500 mm). The vegetation is mainly sour mountain grassland.

The Middleveld lies between the Highveld and the Lowveld and the altitude ranges mainly between 400 m and 1000 m above sea level. Temperatures are warmer and annual rainfall lower (about 900 mm) than the Highveld. The predominant vegetation is open savanna.

The Lowveld is situated at altitudes between 150 m and 400 m above sea level. Mean annual temperature (22 °C) is the warmest and annual rainfall the lowest (500–600 mm) of the four regions. The region is mostly covered with acacia savanna.

The Lubombo Mountains lie in the extreme east of the country and altitude ranges between 400 m and 777 m above sea level. The region is mostly covered by mixed bushveld. The climate of the Lubombo region is very similar to that of the Middleveld region.

Three broad land-use categories were recognized (Monadjem *in press*) viz. public or private nature reserves (hereafter referred to as reserves), privately-owned land and Swazi Nation Land (hereafter referred to as SNL). Almost 60 % of Swaziland falls under SNL which is extensively inhabited by subsistence farmers while the remaining 40 % is mainly under private ownership. Publicly-owned and private nature reserves cover less than 4 % of the total area of Swaziland.

Methods

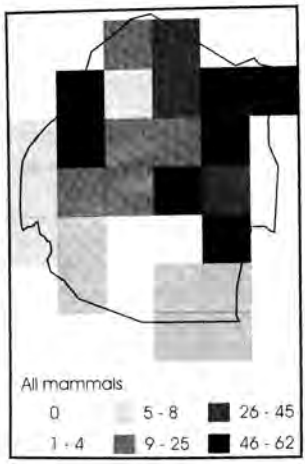
Thirty-nine localities covering all four geographic regions of Swaziland (Monadjem *in press*) were formally sampled. In an attempt to obtain an even coverage of the whole country no two localities within the same eighth-degree square (7.5'×7.5') were sampled. Eleven localities were within public or private nature reserves, eight were on privately-owned land and twenty on SNL.

In addition to the thirty-nine sampled localities, a few specimens were acquired either opportunistically (eg. road kills) or through surveys of short duration (one to two nights) between June 1993 and December 1996.

The thirty-nine localities were sampled for five consecutive nights between June 1994 and August 1996. Terrestrial small mammals were trapped using Longworth and Sherman live-traps and break-back rat/mouse traps. Sampling intensity ranged between 400-800 trap-nights per locality (Monadjem *in press*). All traps were baited with a mixture of peanut butter and oats. Bats were caught in mist-nets which were erected over small bodies of water or at entrances to known roosting sites between dusk and dawn. Some bats were caught in the roosting sites. Carnivores, antelopes and the remaining orders of mammals were recorded as being present if: a) the species was sighted by me in the area (Monadjem *et al. in press*); b) signs (eg. scat, spoor, burrow) of the species were detected by me; or c) the species was reported in a questionnaire sent to various land-owners, reserve wardens and other people considered to have intimate knowledge of the mammalian fauna in their particular area. All seventeen the questionnaires sent out were completed and returned by the respondents. In the questionnaire respondents were asked to list the large mammal species which they had personally seen (or suspected as being present from signs) in their area. To assist with identifications , a complete list of the larger mammal species of Swaziland was attached to questionnaire. Where possible, all records of species not seen by me in a particular locality were confirmed by interviewing other people familiar with the area.

At least one voucher specimen of each species of small mammal was collected from each locality and deposited either in the Transvaal Museum, Pretoria or the Durban Natural Science Museum where my identifications were confirmed. Although *Mastomys natalensis* (*sensu lato*) consists of two sibling species *M. natalensis* and *M. coucha*, these two can only be accurately distinguished karyotypically (Gordon 1978; Green *et al.* 1980), and were therefore considered as *M. natalensis* (*sensu lato*). Although both species are known to occur in Swaziland (Monadjem 1997a), their distributions remain unknown. Sibling species also occur within *Aethomys chrysophilus* (Gordon & Watson 1986; Visser & Robinson 1986; Chimimba 1997), *Thallomys paedulcus* (Taylor *et al.* 1995) and *Dasymys incomtus* (C. Chimimba *pers. comm.*) species groups but could similarly not be distinguished in the present survey.

The final source of information was from records in the Transvaal Museum, Durban Natural Science Museum and The Natural History Museum (London), the only museums found to harbour specimens collected from Swaziland. Information from museum records did not contribute significantly to the mapping of the distributions of Swaziland's mammals since these included less than thirty species most of which were collected from a single locality.



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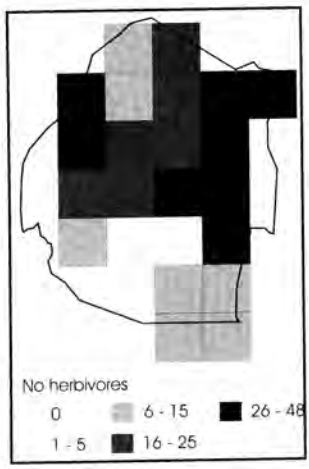

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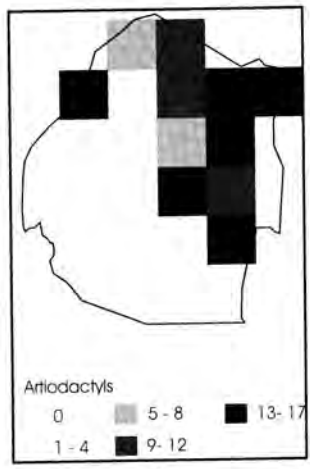

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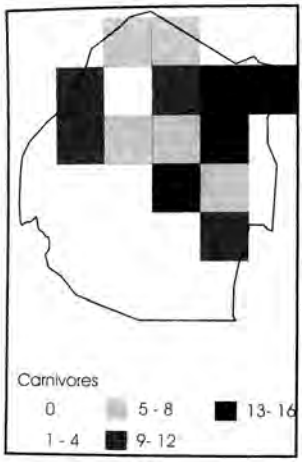

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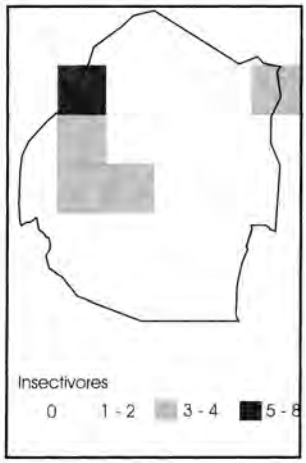

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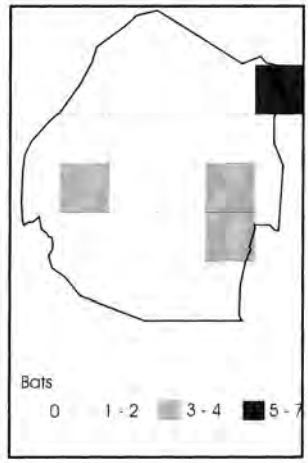

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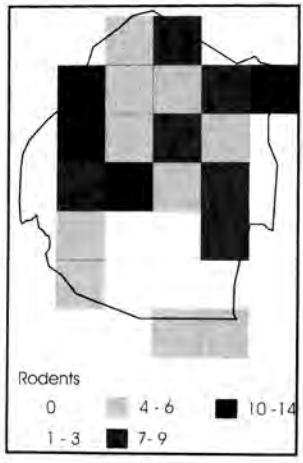

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Fig. 2. Patterns of species richness, at the quarter-degree square scale, of: a) all mammals; b) all mammals except herbivores; c) artiodactyls; d) carnivores; e) insectivores; f) bats; and g) rodents.

The distribution of each mammal species in Swaziland was recorded as being present or absent from each of the thirty-four QDS lying (either entirely or partially) within the boundaries of the country. No sampling was conducted (and hence no mammals were recorded) from five of the thirty-four QDS either because the area covered by Swaziland in that particular QDS was less than a quarter of the QDS (four squares) or because the QDS was situated in an inaccessible part of the country (one square). Species richness in this paper refers to the total number of species recorded.

The number of mammal species in each QDS was correlated with the presence of reserves, privately-owned ranches (to which questionnaires were sent) and each of five vegetation types (taken from Goudie &

Fig. 3. Map of Swaziland showing the quarter-degree squares which contain protected areas (reserves).

Fig. 4. Map of Swaziland showing the quarter-degree squares which contain private ranches sampled, or to which questionnaires were sent, during this study.

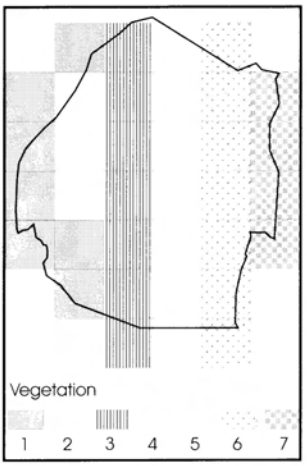

Fig. 5. Map of Swaziland showing the dominant vegetation type(s) in each of the quarter-degree squares: 1) sour mountain grassland; 2) sour mountain grassland-moist grassveld; 3) moist grassveld-dry grassveld; 4) dry grassveld-moist savanna; 5) moist savanna; 6) dry savanna; and 7) mixed bushveld (from Goudie & Price-Williams 1983).

Price-Williams 1983) using partial correlation coefficients (Zar 1984). The sixth vegetation type "mixed bushveld" was recorded from only a single sampled QDS and thus was excluded from the above analyses.

Hierarchical cluster analysis ("between-groups linkage" using SPSS Inc. for Windows 1993) was employed to classify the vegetation types according to the mammal species recorded from each vegetation type. All members of the orders Artiodactyla, Perissodactyla and Proboscidea (hereafter all referred to as "herbivores") were excluded from this analysis since the majority of these species have either been reintroduced to or translocated within Swaziland and thus their current distributions do not necessarily reflect their historical distributions. Furthermore, all large herbivores in Swaziland are currently restricted to reserves (Monadjem 1997a) and thus their distribution patterns would be heavily biased toward the vegetation types occurring within the reserves.

Results

A total of 121 species of mammal were recorded from Swaziland (Appendix 1). The distribution of species richness for all mammals combined, all mammals except the herbivores, and for the five largest orders is shown in Fig. 2. The distribution pattern for all mammals indicates a high species richness in the northeast (NE) and northwest (NW) of the country. A similar pattern is shown for the artiodactyls, rodents, insectivores and all mammals except herbivores. The bats and carnivores show highest species richness in the east (particularly in NE) of Swaziland. Hotspots for mammal species richness, therefore, lie in the NW and NE of the country.

The QDS with protected areas and those with privately-owned cattle ranches to which questionnaires were sent are shown in Figs. 3 & 4, respectively. The distribution of vegetation types by QDS is shown in Fig. 5. Total mammal species richness was positively and highly significantly correlated ($P < 0.001$) with the presence of reserves, moist grassveld and moist savannas and negatively correlated with dry grassveld

Table 1

Partial correlation coefficients for the species richness of seven mammal groups (all mammals, all mammals except herbivores, artiodactyls, carnivores, bats, insectivores and rodents) and the presence of reserves, privately-owned ranches and five vegetation types (sour mountain grassland, moist grassveld, dry grassveld, moist savanna and dry savanna)

Mammal groups	Reserves	Ranches	Sour grassland	Moist grassveld	Dry grassveld	Moist savanna	Dry savanna
All mammals	0.80***	0.08	–0.01	0.69***	–0.51*	0.61***	0.27
All mammals except herbivores	0.73***	0.15	0.08	0.69***	–0.42	0.59**	0.32
Artiodactyls	0.86***	–0.11	–0.21	0.58**	–0.61***	0.56**	0.09
Carnivores	0.73***	–0.10	–0.34	0.38	–0.49*	0.28	–0.06
Bats	–0.31	0.53*	0.53*	0.53*	0.34	0.50*	0.61***
Insectivores	0.13	0.20	0.51*	0.73***	–0.01	0.63***	0.48*
Rodents	0.47*	0.22	0.35	0.73**	–0.24	0.61***	0.41

*P<0.05 **P<0.01 ***P<0.001

(P <0.05) (Table 1). A broadly similar pattern was also shown for all mammals except herbivores, artiodactyls and rodents. Carnivore species richness was positively correlated with reserves (P <0.001) and negatively correlated with dry grassveld (P <0.05). Only the species richness of bats and insectivores was not correlated with the presence of reserves. Except for carnivores, species richness of all mammal groups was positively and significantly correlated with moist grassveld and moist savanna. Except for bats, species richness of all mammal groups was negatively correlated with dry grassveld although these correlations were only significant for all mammals, artiodactyls and carnivores. Only the species richness of bats was significantly correlated with the presence of private ranches (P <0.05).

The results of the hierarchical cluster analysis are shown in Fig. 6. There are similarities between the dendrograms of the different groups. For all groups the sour mountain grassland was distinct from all other vegetation types. Similarly, moist savanna, dry savanna and mixed bushveld were clustered together for all the groups except for the bats. Moist grassveld was distinct for insectivores, rodents and all mammals except herbivores. For bats moist grassveld was clustered with moist savanna and for carnivores, it was clustered with dry grassveld. The general pattern of faunal affinities of the different vegetation types was that the sour mountain grasslands of the Highveld region supported an assemblage of species different from that of the moist savanna, dry savanna and mixed bushveld of the Lowveld and Lubombo regions. The moist grassveld and dry grassveld of the Middleveld region supported an assemblage of species that occurred in both the Highveld and Lowveld vegetation types.

Of the 121 mammals species recorded in Swaziland, 106 species (87.6 %) have been recorded from reserves. The fourteen species which have not been recorded from reserves are listed in Table 2. Of these fourteen species, seven are bats, four are carnivores, one is an insectivore, one a mascroscelidid and one a rodent.

Discussion

Mammal species richness in Swaziland is highest in the QDS containing reserves (NE and NW of the country). It is highly unlikely that this pattern is an artefact of sampling. The QDS containing reserves have neither

Table 2
A list of mammal species not recorded from any of the public or privately-owned reserves within Swaziland

Species (and Order)	Region from which recorded	No. of eighth-degree cells from which recorded
Macroscelidea		
Elephantulus brachyrhynchus	L	1
Insectivora		
Crocidura maquassiensis	M	1
Chiroptera		
Epomophorus crypturus	L	1
Cleotis percivalli	L	1
Miniopterus fraterculus	H	1
Eptesicus capensis	H/M	5
Pipistrellus nanus	H/M	2
Pipistrellus kuhlii	M	1
Scotophilus dinganii	M	1
Rodentia		
Grammomys dolichurus	M	1
Carnivora		
Felis lybica	L	1
Poecilogale albinucha	M	1
Rhyncogale melleri	L	1
Vulpes chama	H	2

L = Lowveld; H = Highveld; M = Middleveld

been sampled more often nor more intensively than those without reserves, at least not for small mammals (Monadjem *in press*). For example, seven of the nine reserves were sampled only once. Furthermore, of the fourteen QDS that had more than one eighth-degree square sampled, only five included reserves. The higher mammalian species richness associated with the reserves may therefore be real.

The high species richness of mammals in the NE area of Swaziland is not surprising since this is part of the lowveld region of South Africa that extends from Kruger National Park in the north to northern KwaZulu-Natal in the south, where species richness is known to be high (Pienaar *et al.* 1993; Freitag & van Jaarsveld 1995; Gelderblom *et al.* 1995; Rowe-Rowe & Taylor 1996). The high mammalian species richness in the NW of the country could be attributed to the two reserves (Malolotja Nature Reserve and Mlilwane Game Sanctuary) in this area to which a large number of antelope species have been introduced. However, the species richness of this area still remains very high after the exclusion of the herbivores. Thus, the high species richness of this area is not merely due to introduced antelope species, but is probably due to its partial overlap of both the Highveld and Middleveld regions. Hence, mammalian species occurring in this area include species restricted to the Highveld as well as many of the Lowveld species (Monadjem 1997a). Within one QDS to the east of Malolotja or Mlilwane, the "Highveld" species disappear (eg. *Rhabdomys pumilio*, *Otomys irroratus*, *Crocidura flavescens*); while one QDS to the west, the "Lowveld" species disappear (eg. *Lemniscomys rosalia*) (Rautenbach 1982).

The lowest total mammalian species richness occurs in the southeast of the country. This may have been partially due to sampling bias. Most of the QDS sampled in this area are within SNL. It has been shown that small mammal species richness is significantly lower on SNL than either on reserves or private ranches (Monadjem *in press*). However, no public reserves occur in this area, and the only private reserve (just outside Nhlangano) had a low mammalian species richness. Furthermore, no large privately-owned ranches could be located in this area. Hence, the low species richness of the southeast of Swaziland may reflect a real paucity of mammal species which nevertheless requires further sampling.

The pattern of insectivore species richness mirrors that for all mammals. High species richness was recorded in the northeast and NW of the country. The reasons for this pattern are not clear but may be related to habitat availability. Most insectivores captured in Swaziland were shrews (Soricidae; Monadjem 1997a). Most of these species require moist habitats with rank vegetation

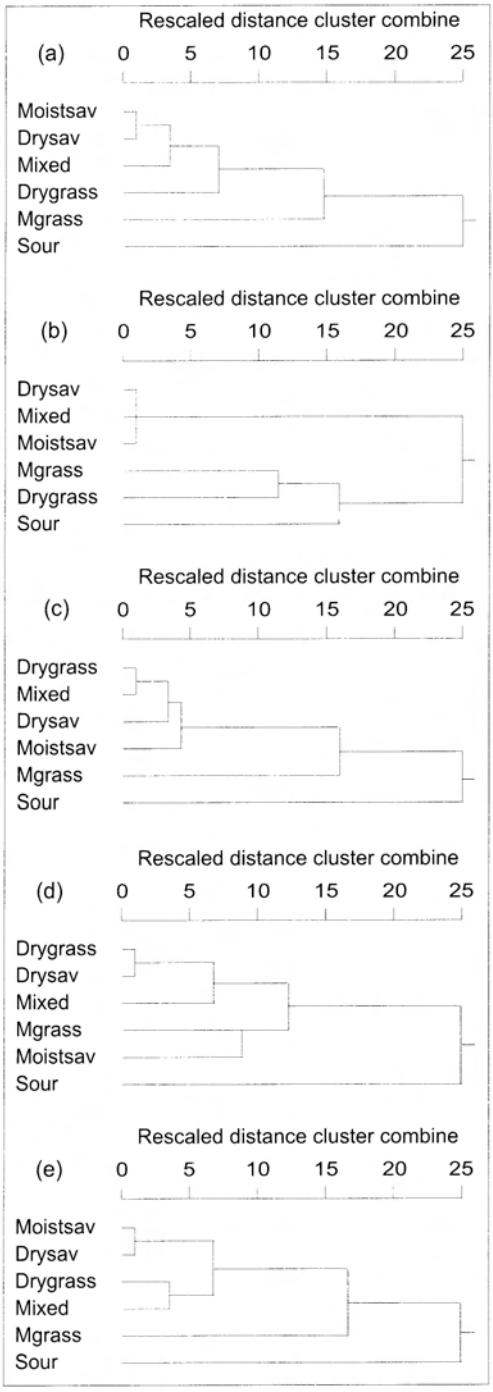

Fig. 6. Hierarchical cluster analysis of five vegetation types (mixed bushveld excluded) based on the mammalian species composition of each vegetation type: a) all mammals except herbivores; b) carnivores; c) insectivores; d) bats; and e) rodents.

or broken, rocky terrain (Rautenbach 1982; Rowe-Rowe & Meester 1982; Skinner & Smithers 1990; Monadjem 1997b). These conditions are most prevalent in the northeast and northwest of the country in the Lubombo Mountains and the Drakensberg Escarpment respectively (Monadjem *in press*).

The bat fauna of Swaziland has been poorly sampled (Monadjem 1997a) and it is likely that many species have been overlooked. As such, not much can be said about the pattern of bat species richness. However, the fact that the area with the highest bat species richness is again in the northeast of the country may suggest that this may not be coincidental.

Rodent species richness was highest in the northeast and northwest of the country. It has been shown that rodent species richness is positively correlated with the amount of grass cover (eg. Bond *et al.* 1980; Kerley 1992) and this is also true for Swaziland (Monadjem 1997b). In Swaziland, grass cover is generally much higher in reserves and private ranches than on SNL (Monadjem *in press*; *pers. obs.*). Very few species of rodents were recorded from "natural" vegetation in SNL, most being captured in maize fields or fallow fields and mostly of the species *Rhabdomys pumilio* (in the Highveld), *Mastomys natalensis* and *Aethomys chrysophilus* (Monadjem *in press*). The paucity of rodents caught in "natural" vegetation in SNL may be due to overgrazing (Monadjem *pers. obs.*). Grass cover is almost nonexistent in many areas (at least for a part of the year) and few indigenous trees remain as a result of the collection of fire wood. Hence, the only species that survive in these areas are rodents adapted to open environments such as *Tatera leucogaster* and *Saccostomus campestris* (De Graaff 1981).

Carnivores, as for most other mammalian orders, show increased species richness in the northeast and northwest areas of Swaziland which was highly correlated with the presence of reserves. There are probably

two reasons for this observation. Firstly, carnivores (especially the larger felids, canids and hyaenids) in southern Africa in particular and worldwide in general have extensively been hunted. For example, lions and other large carnivores were still officially hunted in South Africa's Kruger National Park until the 1950s (Duggan 1983). In Swaziland, large carnivores are restricted mainly to the Lowveld reserves where lions (*Panthera leo*), cheetahs (*Acinonyx jubatus*) and leopards (*Panthera pardus*) have been introduced. Populations of the former two species were hunted to extinction in Swaziland by early this century although a few individuals of the latter species seem to have survived (Monadjem 1997a). Spotted hyaenas (*Crocuta crocuta*) occur only in the northeast where a small indigenous breeding population inhabits the neighbouring Hlane National Park and Mlawula Nature Reserve (Monadjem 1997a). Hyaenas, like the three large felids, occurred widely in Swaziland but have been extensively hunted (Reilly 1985; Reilly & Reilly 1994). Medium-sized predators have also been heavily persecuted, and at present jackals (*Canis mesomelas*) and (*C. adustus*), caracals (*Felis caracal*), servals (*Felis serval*) and honeybadgers (*Mellivora capensis*) occur only in reserves and on a few private ranches. Although recent sightings (since 1990) of the wild dog (*Lycaon pictus*) have been reported from all regions of Swaziland, these are most certainly vagrant individuals originating from neighbouring South Africa. The wild dog is extirpated as a breeding species in Swaziland (Monadjem 1997a) and has not been reintroduced to any of the country's reserves. The smaller carnivores, especially the viverrids, have also suffered persecution albeit for different reasons. Many viverrids such as the slender mongoose *Galerella sanguinea* and the large-spottted genet *Genetta tigrina* are hunted for food. Skins of all viverrids, like most carnivores and artiodactyls, are also used to make "emajobo" (traditional male attire). Thus all carnivores in Swaziland have experienced varying levels of direct persecution to the extent that only the slender mongoose, large-spotted genet, water mongoose (*Atilax paludinosus*) and Cape clawless otter (*Aonyx capensis*) occur in significant numbers in SNL (although the latter species is very rare throughout its range in Swaziland).

The second reason for the high correlation between carnivore species richness and reserves may be due to the dramatic habitat alteration that has occurred on SNL and crop farms. Habitat alteration (Happold 1995) may affect the carnivores directly by, for example, reducing the amount of cover available for the survival of carnivores. An altered habitat may also affect the carnivores' prey by, for example, reducing the density of rodents on SNL which could cause the extinction of rodent-eating carnivores in the area. However, at least one species of carnivore, the slender mongoose, appears to have benefitted from habitat alteration in Swaziland.

Artiodactyls show an almost identical distribution pattern of species richness in being highly correlated with reserves. Most large herbivores were hunted to extinction by early this century (Reilly 1985; Reilly & Reilly 1994) including buffalo (*Syncerus cafer*), elephant (*Loxodonta africana*), and both species of rhino (*Ceratotherium simum*) and (*Diceros bicornis*) (Table 3). Extinction was not restricted to the large species only, and smaller species such as the warthog (*Phacochoerus aethiopicus*) also became extirpated (Reilly 1985). The reasons for artiodactyl extinctions are probably similar to those for carnivores. Extensive hunting led to the extirpation of the above-mentioned herbivore species and certain others (see Table 3) and the decimation of the large herds of migratory wildebeest (*Connochaetes taurinus*) and zebra (*Equus burchelli*) which were reduced to a single small population withinin the present Hlane National Park (Reilly & Reilly 1994). Some of the species that became extinct and have been subsequently reintroduced into Swaziland (see Table 3 and Appendix 1). Lichtenstein's hartebeest *Alcelaphus lichtensteini* did occur formerly in Swaziland (du Plessis 1969; Milstein 1989) but became extinct in the

Table 3
Listed below are all the mammal species (formerly extinct or not known to have occurred within the boundaries of Swaziland in historic times) which have been introduced to Swaziland

Introduced species (and Order)	Present in historic times
Carnivora	
Acinonyx jubatus	Yes
Panthera pardus[1]	Yes
Panthera leo	Yes
Proboscidea	
Loxodonta africana	Yes
Perissodactyla	
Ceratotherium simum	Yes
Diceros bicornis	Yes
Artiodactyla	
Phacochoerus aethiopicus	Yes
Hippopotamus amphibius[1]	Yes
Giraffa camelopardalis	No?
Syncerus caffer	Yes
Tragelaphus angasii	Yes
Taurotragus oryx	Yes
Redunca arundinum	Yes
Kobus ellipsiprymnus[1]	Yes
Hippotragus niger	No?
Hippotragus equinus	Yes
Connochaetes gnou	No
Alcelaphus buselaphus	No
Damaliscus dorcus phillipsi	No?
Damaliscus lunulatus	Yes

[1]Small numbers of these species still occurred within Swaziland at the time of reintroduction

early part of this century and has not been reintroduced subsequently and hence not included in Table 3. Other species such as the giraffe (*Giraffa camelopardalis*), sable (*Hippotragus niger*) and blesbuck (*Damaliscus dorcus phillipsi*) probably did not occur in Swaziland in recent historical times (du Plessis 1969; Goodman & Tomkinson 1987), while the black wildebeest (*Connochaetes gnou*) and red hartebeest (*Alcelaphus buselaphus*)almost certainly did not occur (du Plessis 1969; Skinner & Smithers 1990).

Although, small-scale hunting (or "poaching") may not have been responsible for extinctions in the early parts of this century (Reilly 1985), from the 1950s it probably led to the recent extermination of the remaining few artiodactyls from SNL, and many landowners consider these species on their currently unguarded private ranches to be threatened. Of the thirty species of artiodactyls and associated large herbivores occurring in Swaziland only the grey duiker (*Sylvicapra grimmia*) still occurs regularly as a breeding species in SNL, albeit only in remote areas or those abutting reserves and private ranches.

In terms of the species composition of the different vegetation types, the sour mountain grasslands supported a mammalian fauna distinct from that of the other vegetation types. The species composition of the moist and dry savannas and mixed bushveld were very similar, with the species composition of the dry grassveld resembling that of the Lowveld vegetation types but with a greatly reduced number of species. The moist grassveld had a species composition consisting of elements of both Highveld sour grasslands and Lowveld savannas. Thus, in terms of mammalian distribution patterns in Swaziland there appear to be two broad "zones": a) the Highveld species, and b) the Lowveld species with a certain amount of overlap occurring in the upper Middleveld region. The pattern shown by the mammalian fauna in Swaziland is similar to that of Swaziland's amphibians (Poynton & Boycott 1996).

For adequate conservation of the mammals of Swaziland, reserves (or their equivalents) are required in, at least, the Highveld and Lowveld regions, and preferably in the northeastern and northwestern areas. Reserves already do exist in these areas. There appears to be an evenly distributed reserve network in Swaziland, except for the SW which, in any case, appears depauperate in so far as mammals are concerned. This even distribution of reserves may be the reason why only a few (14) species of mammals are not represented in the country's reserve

network. Of these, one (*Crocidura maquassiensis*) is a taxonomic enigma (Meester 1963; Rautenbach 1982; Skinner & Smithers 1990) and seven are bats that have almost certainly been overlooked in the country's reserves. Of the remaining five species *Grammomys dolichurus*, *Felis lybica*, *Vulpes chama* and *Elephantulus brachyrhynchus* are very common in other parts of southern Africa where they occur in numerous reserves and national parks (Skinner & Smithers 1990) while *Rhyncogale melleri* may occur at Mlawula Nature Reserve (J. Culverwell *pers. comm.*). Both *R. melleri* and *Poecilogale albinucha* are listed as rare in the South African Red Data Book (Smithers 1986). Furthermore, *R. melleri* is listed as a species which requires "additional protection" in southern Africa (Gelderblom *et al.* 1995). The fact that neither of these two species is known to occur within reserves in Swaziland is, thus, a matter of concern.

This study was based on the distribution of mammalian species richness. Since hotspots of species richness, endemism and rarity rarely coincide (Crowe 1990; Siegfried & Brown 1992; Gelderblom & Bronner 1995) it has been suggested that these three forms of hotspots be analyzed separately (Lombard 1995). However, there are no mammal species endemic to Swaziland with only eight species of southern African endemics (Siegfried & Brown 1992; Gelderblom & Bronner 1995) present (Monadjem 1997a), of which two have been introduced and all eight occur within reserves (see Table 4).

Table 4
Southern African endemic mammal species recorded from Swaziland. All eight species have been recorded from at least one reserve in Swaziland

Southern African endemic species
Insectivora
Crocidura flavescens
Myosorex varius
Suncus infinitesimus
Amblysomus hottentotus
Lagomorpha
Pronolagus crassicaudatus
Artiodactyla
Connochaetes gnou[1]
Damaliscus dorcus phillipsi[1]
Pelea capreolus

[1]Introduced to Swaziland

In conclusion, the present distribution of most large mammals (above 5 kg) in Swaziland is determined by the presence of either reserves or privately-owned ranches. Very few, both in terms of the number of individuals and the number of species, of these large (or, indeed, of the small) mammals survive on SNL. The size of reserves and private ranches in Swaziland, however, are relatively small with the largest reserve, Hlane National Park, covering less than 30 000 ha (Reilly & Reilly 1994). Hence, viable populations of the larger species may not be possible (Soulé *et al.* 1979) without direct intervention by reserve management through, for example, continuous reintroductions and supplementary or artificial feeding programmes. The formation of conservancies (Earle 1991) may be a way of increasing the size of conservation areas. The creation of community-owned reserves or sanctuaries (Martin 1986) on SNL should also be investigated, especially in areas abutting existing reserves or privately-owned game farms. These reserves would allow the recolonization of SNL with indigenous mammals which would increase the distributional ranges and numbers of these species in Swaziland. Furthermore, these reserves could, if managed properly, play an important role in the socio-economic development of some of the SNL areas (Child & Peterson 1991).

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References

ANSELL, W.F.H. 1978. *The Mammals of Zambia*. Chilanga: The National Parks and Wildlife Service.

ANSELL, W.F.H. & R.J. DOWSETT. 1988. *Mammals of Malawi*. Cornwall: Trendine Press.

BOND, W., M. FERGUSON & G. FORSYTH. 1980. Small mammals and habitat structure along altitudinal gradients in the southern Cape mountains. *South African Journal of Zoology* 15: 34-43.

CHILD, B. & J.H. PETERSON. 1991. *CAMPFIRE in rural development the Beitbridge experience*. Harare: Branch of Terrestrial Ecology, Department of National Parks and Wildlife Management.

CHIMIMBA, C.T. 1997. A systematic revision of southern African *Aethomys* Thomas, 1915 (Rodentia: Muridae). Ph.D thesis. Pretoria: University of Pretoria.

CROWE, T.M. 1990. A quantitative analysis of patterns of distribution, species richness and endemism in southern African vertebrates. Pp. 145-160. *In:* PETERS, G. & R. HUTTERER (eds.). *Vertebrates in tropics*. Bonn: Museum Alexander Koenig.

DE GRAAFF, G. 1981. *The Rodents of Southern Africa*. Durban: Butterworths.

DUGGAN, A. (ed.). 1983. *Reader's Digest illustrated guide to the game parks and nature reserves of southern Africa*. Cape Town: Reader's Digest Association of South Africa.

DU PLESSIS, S.F. 1969. The past and present distribution of the Perissodactyla and Artiodactyla in southern Africa. M.Sc. thesis. Pretoria: University of Pretoria.

EARLÉ, R. 1991. The story of the Orange Free State conservancy concept. *African Wildlife* 45: 141-143.

FREITAG, S. & A.S. VAN JAARSVELD. 1995. Towards conserving regional mammalian species diversity: a case study and data critique. *South African Journal of Zoology* 30: 136-144.

GELDERBLOM, C.M. & G.N. BRONNER. 1995. Patterns of distribution and current protection status of the endemic mammals in South Africa. *South African Journal of Zoology* 30: 127-135.

GELDERBLOM, C.M., G.N. BRONNER, A.T. LOMBARD & P.J. TAYLOR. 1995. Patterns of distribution and current protection status of the Carnivora, Chiroptera and Insectivora in South Africa. *South African Journal of Zoology* 30: 103-114.

GOODMAN, P.S. & A.J. TOMKINSON. 1987. The past and present distribution of giraffe in Zululand and its implications for reserve management. *South African Journal of Wildlife Research* 17: 28-32.

GORDON, D.H. 1978. Distribution of sibling species of the *Praomys* (*Mastomys*) *natalensis* group in Rhodesia (Mammalia: Rodentia). *Journal of Zoology, London* 186: 397-401.

GORDON, D.H. & C.R.B. WATSON. 1986. Identification of cryptic species of rodents (*Mastomys*, *Aethomys*, *Saccostomus*) in the Kruger National Park. *South African Journal of Zoology* 21: 95-99.

GOUDIE, A. & D. PRICE-WILLIAMS. 1983. *The atlas of Swaziland*. Mbabane: Swaziland National Trust Commission.

GREEN, C.A., H. KEOGH, D.H. GORDON, M. PINTO & E.K. HARTWIG. 1980. The distribution, identification, and naming of the *Mastomys natalensis* species complex in southern Africa (Rodentia: Muridae). *Journal of Zoology, London* 192: 17-23.

HAPPOLD, D.C.D. 1995. The interactions between humans and mammals in Africa in relation to conservation: a review. *Biodiversity and Conservation* 4: 395-414.

KERLEY, G.I.H. 1992. Ecological correlates of small mammal community structure in the semi-arid Karoo, South Africa. *Journal of Zoology, London* 227: 17-27.

LOMBARD, A.T. 1995. Introduction to an evaluation of the protection status of South Africa's vertebrates. *South African Journal of Zoology* 30: 63-70.

LYNCH, C.D. 1983. The mammals of the Orange Free State. *Navorsinge van die Nasionale Museum, Bloemfontein* 18: 1-218.

LYNCH, C.D. 1989. The mammals of the north-eastern Cape Province. *Navorsinge van die Nasionale Museum, Bloemfontein* 25: 1-116.

LYNCH, C.D. 1994. The mammals of Lesotho. *Navorsinge van die Nasionale Museum, Bloemfontein* 10: 177-241.

MARTIN, R.B. 1986. *Communal Areas Management Programme for Indigenous Resources (CAMPFIRE)*. Harare: Branch of Terrestrial Ecology, Department of National Parks and Wildlife Management.

MEESTER, J. 1963. A systematic revision of the shrew genus Crocidura in southern Africa. *Transvaal Museum Memoirs* 13: 1-127.

MILSTEIN, P. LE S. 1989. Historical occurrence of Lichtenstein's hartebeest *Alcelaphus lichtensteini* in the Transvaal and Natal. *Aepyceros* 2: 1-141.

MONADJEM, A. 1997a. *An Annotated Checklist of the Mammals of Swaziland.* Manzini: Conservation Trust of Swaziland.

MONADJEM, A. 1997b. Habitat preferences and biomasses of small mammals in Swaziland. *African Journal of Ecology* 35: 64-72.

MONADJEM, A. (*In press*). Geographic distribution patterns of small mammals in Swaziland in relation to abiotic factors and human land-use activity. *Biodiversity & Conservation.*

MONADJEM, A., MONADJEM, L. & J. PUTNAM. (*In press*). Sighting frequencies of nocturnal mammals in Swaziland. *African Journal of Ecology.*

MUGO, D.N., A.T. LOMBARD, G.N. BRONNER, C.M. GELDERBLOM & G.A. BENN. 1995. Distribution and protection of endemic or threatened rodents, lagomorphs and macroscelids in South Africa. *South African Journal of Zoology* 30: 115-126.

PIENAAR, U. DE V., S.C.J. JOUBERT, A. HALL-MARTIN, G. DE GRAAFF & I.L. RAUTENBACH. 1993. *Field guide to the mammals of the Kruger National Park.* Cape Town: Struik Publishers.

POYNTON, J.C. & R.C. BOYCOTT. 1996. Species turnover between Afromontane and eastern African lowland faunas: patterns shown by amphibians. *Journal of Biogeography* 23: 669-680.

RAUTENBACH, I.L. 1982. Mammals of the Transvaal. *Ecoplan Monographs* 1: 1-211.

REILLY, T.E. 1985. *The Mlilwane story. A history of nature conservation in the Kingdom of Swaziland and fund raising appeal.* Mbabane: The Mlilwane Trust.

REILLY, T.E. & L. REILLY. 1994. *The lion roars again.* Mbabane: Hlane National Park.

ROWE-ROWE, D.T. & J. MEESTER. 1982. Habitat preferences and abundance relations of small mammals in the Natal Drakensberg. *South African Journal of Zoology* 17: 202-209.

ROWE-ROWE, D.T. & P.J. TAYLOR. 1996. Distribution patterns of terrestrial mammals in KwaZulu-Natal. *South African Journal of Zoology* 31: 131-144.

SHORTRIDGE, G.C. 1934. *The Mammals of South West Africa.* Vols I & II. London: Heinemann .

SIEGFRIED, W.R. & C.A. BROWN. 1992. The distribution and protection of mammals endemic to southern Africa. *South African Journal of Wildlife Research* 22: 11-16.

SKINNER, J.D. & R.H.N. SMITHERS. 1990. The Mammals of the Southern African subregion. Pretoria: University of Pretoria.

SMITHERS, R.H.N. 1971. *The mammals of Botswana.* Salisbury: Trustees of the National Museums and Monuments of Rhodesia. (Museum Memoir No. 4).

SMITHERS, R.H.N. 1986. *South African red data book – terrestrial mammals.* Pretoria: Council for Scientific and Industrial Research, National Scientific Programmes Unit. (South African National Scientific Programmes report; no. 125.)

SMITHERS, R.H.N. & J.L.P. LO TELLO. 1976. *Check list and atlas of the mammals of Mozambique.* Salisbury: Trustees of the National Museums and Monuments of Rhodesia. (Museum Memoir No. 8).

SMITHERS, R.H.N. & V.J. WILSON. 1979. *Check list and atlas of mammals of Zimbabwe Rhodesia.* Salisbury: Trustees of the National Museums and Monuments of Rhodesia. (Museum Memoir No. 9).

SOULÉ, M.E., B.A. WILCOX & C. HOLTBY. 1979. Benign neglect: a model of faunal collapse in the game reserves of East Africa. *Biological Conservation* 15: 259-272.

TAYLOR, P.J., I.L. RAUTENBACH, D. GORDON, K. SINK & P. LOTTER. 1995. Diagnostic morphometrics and southern African distribution of two sibling species of tree rat, *Thallomys paedulcus* and *Thallomys nigricauda* (Rodentia: Muridae). *Durban Museum Novitates* 20: 49-62.

VAN JAARSVELD, A.S. 1995. Where to with reserve selection and conservation planning. *South African Journal of Zoology* 30: 164-168.

VISSER, D.S. & T.J. ROBINSON. 1986. Cytosystematics of the South African *Aethomys* (Rodentia: Muridae). *South African Journal of Zoology* 21: 264-268.

WILSON, E.O. 1992. *The diversity of life.* London: Penguin Books.

ZAR, J.H. 1984. *Biostatistical analysis* (2nd Ed). London: Prentice-Hall.

APPENDIX 1

Mammal species recorded from Swaziland and the vegetation types from which they were recorded: SG = sour mountain grassland; MG = moist grassveld; DG = dry grassveld; MS = moist savanna; DS = dry savanna; MB = mixed bushveld. Open circles = introduced species

Order and species	SG	MG	DG	MS	DS	MB
Macroselidea						
Elephantulus brachyrhynchus				•		
Insectivora						
Myosorex varius	•	•				
Myosorex cafer	•					
Suncus lixus	•					
Suncus infinitesimus	•					
Crocidura flavescens	•					
Crocidura cyanea	•	•				
Crocidura hirta			•	•	•	•
Crocidura mariquensis	•	•				
Crocidura maquassiensis		•				
Crocidura fuscomurina					•	
Crocidura silacea			•		•	
Amblysomus hottentotus	•					
Chiroptera						
Epomophorus wahlbergi		•	•	•	•	•
Epomophorus crypturus					•	
Taphozous mauritianus					•	
Nycteris thebaica		•		•	•	•
Rhinolophus clivosus	•					
Rhinolophus darlingi						•
Rhinolophus simulator				•		
Hipposideros caffer						•
Cleotis percivali				•		
Miniopterus schreibersii	•					
Miniopterus fraterculus	•					
Nycticeius schlieffenii						•
Pipistrellus nanus	•	•				
Pipistrellus kuhlii		•				
Eptesicus capensis	•	•				
Scotophilus dinganii		•				
Tadarida condylura			•		•	•
Tadarida pumila		•	•	•	•	•
Tadarida aegyptiaca					•	
Primates						
Papio ursinus	•	•		•	•	•
Cercopithecus aethiops	•	•	•	•	•	•
Cercopithecus mitis						•
Galago crassicaudatus	•	•	•	•	•	•
Pholidota						
Manis temminckii				•	•	•
Lagomorpha						
Pronolagus crassicaudatus	•					•
Lepus saxatilis	•	•	•	•	•	•
Rodentia						
Cryptomys hottentotus	•				•	
Thryonomys swinderianus	•	•	•	•	•	•
Hystrix africaeaustralis	•	•				•
Graphiurus platyops	•					
Graphiurus murinus	•	•				
Aethomys namaquensis	•	•	•	•	•	•
Aethomys chrysophilus	•	•	•	•	•	•
Dasymys incomtus		•				
Lemniscomys rosalia		•	•	•	•	•
Rhabdomys pumilio	•	•				
Mus minutoides	•	•	•	•	•	•
Mastomys natalensis	?	?	?	?	?	?
Mastomys coucha	?	?	?	?	?	?
Rattus rattus[1]						
Thallomys paedulcus				•	•	
Grammomys dolichurus		•				
Saccostomus campestris				•	•	•
Dendromus melanotis	•					
Dendromus mesomelas	•					
Dendromus mystacalis	•	•	•	•	•	•
Steatomys pratensis		•	•	•	•	•
Tatera leucogaster			•	•	•	•
Otomys angoniensis		•	•			•
Otomys irroratus	•	•				
Carnivora						
Lycaon pictus[2]						
Vulpes chama	•					
Canis adustus				•	•	•
Canis mesomelas	•	•	•	•	•	•
Aonyx capensis	•	•	•	•	•	•
Mellivora capensis				•	•	•
Ictonyx striatus		•	•	•	•	•
Poecilogale albinucha		•				
Viverra civetta	•	•	•	•	•	•

Order and species	SG	MG	DG	MS	DS	MB
Genetta tigrina	•	•	•	•	•	•
Herpestes ichneumon						•
Galerella sanguineus	•	•	•	•	•	•
Rhyncogale melleri				•		
Ichneumia albicauda		•		•		•
Atilax paludinosus		•	•	•	•	•
Mungos mungo				•	•	•
Helogale parvula			•	•	•	•
Proteles cristatus	•					
Crocuta crocuta					•	•
Acinonyx jubatus					○	
Panthera pardus	•	•			○	○
Panthera leo					○	
Felis serval	•	•		•	•	•
Felis caracal		•		•	•	
Felis lybica					•	
Tubulidentata						
Orycteropus afer	•	•		•	•	•
Proboscidea						
Loxondonta africana					○	
Hyracoidea						
Procavia capensis	•					
Perissodactyla						
Ceratotherium simum				○	○	
Diceros bicornis				○		
Equus burchelli	○	○		○	•	•

Order and species	SG	MG	DG	MS	DS	MB
Artiodactyla						
Potamochoerus porcus	•	•	•	•	•	•
Phacochoerus aethiopicus	○	○		○	○	○
Hippopotamus amphibius		○		○	•	
Giraffa camelopardalis		○		○	○	
Syncerus caffer				○		
Tragelaphus angasii		○		○	○	○
Tragelaphus scriptus		•		•	•	•
Tragelaphus strepsiceros		○	•	•	•	•
Taurotragus oryx	○				○	
Cephalophus natalensis	•	•		•	•	•
Sylvicapra grimmia	•	•	•	•	•	•
Redunca arundinum	•	○		○	○	○
Redunca fulvorufula	•					•
Kobus ellipsiprymnus		○		○	•	•
Hippotragus niger				○		
Hippotragus equinus				○		
Connochaetes gnou	○					
Connochaetes taurinus	○	○		○	•	•
Alcelaphus buselaphus	○					
Damaliscus dorcus	○	○				
Damaliscus lunulatus				○		
Aepyceros melampus	○	○	•	•	•	•
Oreortagus oreotragus	•					•
Ourebia ourebi	•					•
Raphicerus campestris		○	•	•	•	•
Raphicerus sharpei						•
Pelea capreolus	•					

[1]*The distribution of this species is associated only with human settlement*
[2]*Extinct within Swaziland, although vagrants do occasionally enter the country*