Checklist and Centres of Vertebrate Diversity in Mozambique

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Keywords: biological diversity, endemism, Red List, threatened species, protected species

SUMMARY

A checklist of vertebrates of Mozambique was elaborated by means of revision of monographic and web-based resources. During interviews of native speakers made in various parts of Mozambique, vernacular names of vertebrates in the 20 most important languages were assessed and included in the checklist as well as their common names in Portuguese and English. Additional information such as the category of Red List of threatened species, conservation status according to the Forest and Wildlife Law and Regulation of Mozambique, the Convention on the International Trade in Endangered Species of Flora and Fauna (CITES) and the Convention on Migratory Species (CMS) is provided.

According to this analysis, 3470 vertebrate species occur in Mozambique, of which 271 (7.8%) species are mammals, 816 (23.5%) species of birds, 280 (8.0%) species of reptiles, 84 (2.4%) species of amphibians and 2019 (58.2%) species of fish. 503 vertebrate species are considered as threatened by extinction and protected by national and international legislation, i.e. 38.7% of the mammal species, 36.0% of the birds, 11.8% of the reptiles, 3.6% of the amphibians and 3.4% of the fish species. Mozambique has 234 endemic or near endemic species of vertebrates, which are 7.7% of the mammal species, 14.1% of the birds, 32.5% of the reptiles, 2.4% of the amphibians and 0.2% of the fish species. 20 (0.6%) vertebrate species were introduced into Mozambique, i.e. 1.1% of the mammals, 0.4% of the birds, 0.4% of the reptiles and 0.6% of the fish species.

Digitizing, vectorization, georeferencing and processing of distribution maps using MapScan 1.0 and ArcView GIS 3.2 enabled the superposition of the distribution maps and the subsequent identification of diversity centres of vertebrates as well as ‘hotspots’ of endemic, threatened and protected terrestrial vertebrate species of Mozambique.

In Mozambique, these conservation ‘hotspots’ generally occur in (i) the region of Mount Gorongosa - Rift Valley - Marromeu Complex in Sofala and Manica Provinces, (ii) the mountains of the Chimanimani region in Manica Province, (iii) along the Lebombo mountain range in Gaza and Maputo Provinces, (iv) along the coast of Inhambane, Gaza and Maputo Provinces, (v) the Mozambican part of Maputaland region in the south of Maputo Province, (iv) the region of Panda in Inhambane Province and (v) the Great Inselberg Archipelago in Zambézia and Nampula Provinces including Mount Chiperone and Mount Namúli. A comparison shows, that some conservation ‘hotspots’ are not adequately represented in the existing network of protected areas of Mozambique. These areas are the mountains in the north of the Chimanimani National Reserve in Manica Province, the coastal area north of Beira in Sofala Province, the coastal areas of Inhambane, Gaza e Maputo Provinces, the region of Panda in Inhambane Province as well as the Great Inselberg Archipelago in Zambézia and Nampula Provinces.

The lack of information on the occurrence and distribution of vertebrates in Mozambique north of the Zambeze River greatly limited the identification of conservation ‘hotspots’ in this part of the country.

INTRODUCTION

The loss of biodiversity poses a great threat to mankind and nature. Conventional approaches to mitigate such losses are often rather unsuccessful because action often occurs on species level and, when a species is already at the verge of extinction (Scott *et al.*, 1993; Cox, 1997). The Convention on Biological Diversity provides a solution to this problem by promoting *in situ* conservation of species and ecosystems in protected areas such as national parks and reserves (UNEP, 1992).

Formerly, protected areas were often selected and set aside for economic and political reasons without considering the varied interactions between living organisms and their environment (Scott *et al.*, 1993). This has changed. Now the selection and planning process seriously considers the biological, environmental and social factors as well as the understanding that biological boundaries do not obey administrative frontiers (Scott *et al.*, 1993).

The Convention on Biological Diversity legally binds member countries to protect their flora and fauna, ecosystems and inherent ecological processes (UNEP, 1992). Therefore, the Government of Mozambique through the Ministry of Environment defines the conservation of biological diversity as a prime national goal (MICOA, 2003). Planning, designation, establishment and management of protected areas are the most important steps of any national strategy for the conservation of natural resources and biodiversity. One of the major difficulties during the planning process is the lack of baseline data on biological diversity. Conservation needs assessment of the elements of biodiversity and long-term planning are impossible without detailed data (Sutherland, 2000).

Gaps in the representation of elements of biological diversity within a network of protected areas pose a potential threat of extinction of these elements and therefore gap analysis is required to mitigate human impacts such as habitat destruction and the subsequent loss of species (Crist & Csuti, 2000). On the other hand, the identification of species rich areas is an additional filter in the analysis and planning of protected areas (Csuti & Crist, 2000).

A Geographic Information System (GIS) is a useful tool for the analysis of the representation of elements of biodiversity in a network of protected areas (Csuti & Crist, 2000). GIS allows the quick processing of large quantities of complex spatial information relevant for the planning process and management of protected areas at relatively low costs. The system consists of a computer-based mapping programme that links map characteristics with their geographic coordinates and allows the manipulation, analysis and presentation of spatial data in form of a matrix or vector (Crist & Csuti, 2000; Csuti & Crist, 2000).

Apart from a variety of field guides of vertebrates of southern Africa, usually including only the area south of the Zambeze River, little information on occurrence and distribution of vertebrates in the north of Mozambique is available. The only comprehensive compilation of information on mammals of Mozambique is now almost 30 years old (Smithers & Tello, 1976). Parker (2000) published an atlas of birds south of the Save River in Mozambique, two other parts covering the centre and north of Mozambique are in preparation. The entire territory of Mozambique is included in Channing's (2001) guide on amphibians. A comprehensive field guide exists for commercial marine species of fish (Fischer *et al.*, 1990). Therefore, an update and compilation of the vertebrate species of Mozambique was urgently required. Additionally, vernacular names of vertebrates in the most important local languages of Mozambique were not available for most vertebrate species, apart from those provided by Dias (1975) for large and charismatic mammals. Common names in Portuguese only existed for certain species of mammals (Dias, 1975; Smithers & Tello, 1976), birds (Parker, 2000) and fish (Fischer *et al.*, 1990).

One of the objectives of this study is to update and compile a checklist of vertebrates of Mozambique including various information such as common names in Portuguese and English, vernacular names, conservation status like protected species, species listed in the appendices of the Convention on the International Trade in Endangered Species of Flora and Fauna (CITES) and the Convention on Migratory Species (CMS), category of Red List of endangered species and introduced species. The second objective is to identify centres of terrestrial vertebrate diversity as well as centres of endemic, threatened and protected vertebrate species and to assess the representation of these 'hotspots' in the network of protected areas of Mozambique.

MATERIALS AND METHODS

Selection of species

The selection of vertebrate species was made according to the distribution maps of field guides or web-based resources. The selection was conservative as some species were included in the checklist, whose occurrence in Mozambique is not confirmed but probable. For example the checklist comprises species that are found in a neighbouring country near the Mozambican boarder. In this case, the species most probably also occurs in Mozambique but assessments were not carried out on the Mozambican side of the boarder.

The following field guides and monographs were used for mammals: Dias (1975), Smithers & Tello (1976), Kingdon (1997), Boitani *et al.* (1999), Stuart & Stuart (2001a, b); birds: MacLean (1985), Sinclair *et al.* (1997), Parker (2000), Sinclair & Ryan (2003); reptiles: Branch (1998), Spawls *et al.* (2001); amphibians: Carruthers (2001), Channing (2001) and fish: Fischer *et al*. (1990), Skelton (2001). Web-based sources were (1998), Frost (2000) and Froese & Pauly (2004).

Marine species of mammals, birds and fish were not considered for the identification of 'hotspots' of vertebrate diversity, endemism and threats.

Nomenclature, taxonomy and classification

The nomenclature, taxonomy and classification was followed according to Wilson & Reeder (1993) for mammals, Peterson (2004) for birds, Uetz (1998) for reptiles, Frost (2000) for amphibians and Froese & Pauly (2004) for fish.

Assessment of vernacular names

The classification system of vernacular names proposed by Koning (1993) was adopted in this study, considering the following main languages of Mozambique: Shangaan, Chironga, Chope, Chitsua, Guitonga, Chindau, Cishona, Chisena, Angone, Chiunda, Echuawabo, Ekoti, Elomwe, Emakhuwa**,** Chirima, Kiswahili, Shimakonde, Cinyanja and Ajáua. Fig. 1 shows the distribution of these vernacular languages in Mozambique.

Semi-structured interviews of native speakers were carried out presenting field guides with photographs or sketches of vertebrates asking for the respective vernacular names. In order to check the trustworthiness of the obtained names, usually two persons were interviewed independently.

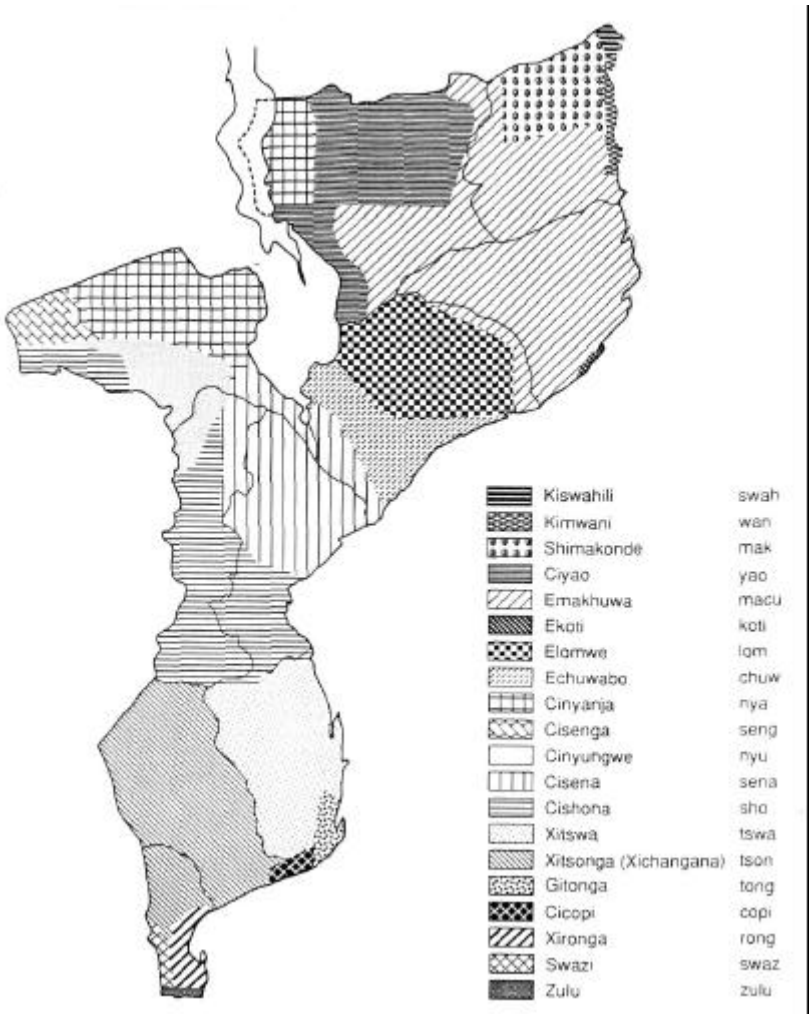


Figure 1 Distribution of vernacular languages of Mozambique (taken from de Koning, 1993)

Translation of common names into Portuguese

Common names in Portuguese existed for larger species of mammals, birds and reptiles as well as of charismatic, dangerous, useful species or vertebrates of any other public interest (Dias, 1975; Smithers & Tello, 1976; Fischer *et al*., 1990; Parker, 2000). However, the vast majority of vertebrates did not have a Portuguese name. Existing Portuguese names were adopted from the respective sources and included into the checklist, otherwise new names were created by Dr. Augusto Cabral, Director of the Natural History Museum, Maputo based on the common name in English and/or the meaning of the scientific name.

Assessment of conservation status

The conservation status of vertebrate of Mozambique was included in the checklist according to the Forests and Wildlife Regulation of Mozambique (DNFFB, 2002), the latest version of Appendices I or II of the Convention on Migratory Species (CMS, 2002) and Appendices I or II of the Convention on the International Trade in Endangered Species of Flora and Fauna (CITES, 2005). Regarding CITES, there are no species listed in Appendix III for Mozambique. The categories of the Red List of species threatened by extinction were assessed according to IUCN (2003) using the categories shown in Tab. 1. Information on endemic and introduced species was also added to the checklist according to the used monographic and web-based sources.

Table 1 Categories of the Red List of species threatened by extinction according to IUCN (2003)

EX	extinto		extinct	
EW	extinto na natureza		extinct in the wild	
CR	em perigo crítico	**ameaçado**	critically endangered	**threatened**
EN	em perigo		endangered	
VU	vulnerável		vulnerable	
NT	quase ameaçado		near threatened	
LC	preocupação menor		least concern	
DD	dados insuficientes		data deficient	
NE	não avaliado		not evaluated	

Digitizing, vectorization e georeferencing of distribution maps

Distribution maps were digitized using a scanner with a resolution between 200 dpi and 600 dpi depending on the size of the map, producing images in 8 bit 'greyscale'. Fig. 2a shows the resulting digitized map.

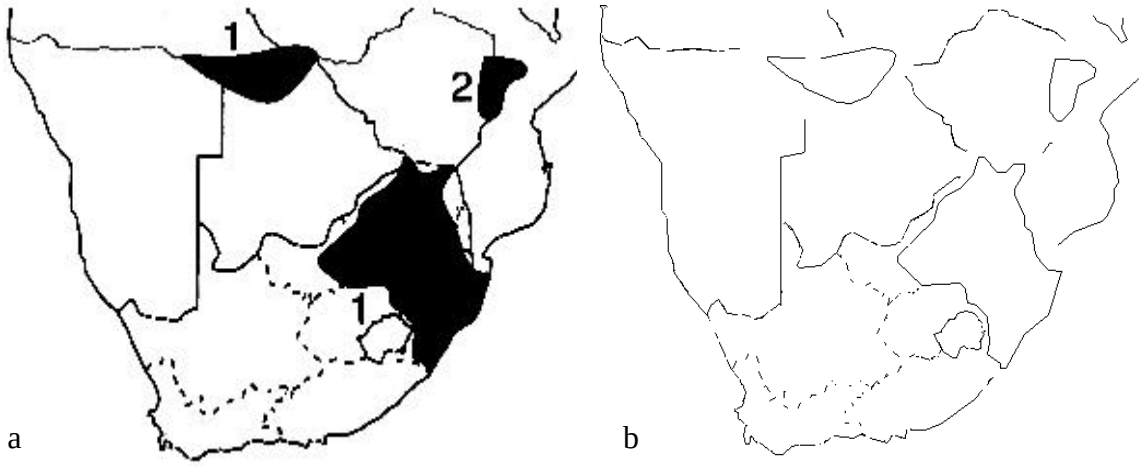


Figure 2 Example of a distribution map as a scanned image (a) and as a vector map (b) (taken from Stuart & Stuart, 2001b)

After editing e.g. adjusting the contrast of the digital images, the digitized distribution maps were vectorized and georeferenced using the software MapScan (United Nations UNDESA-UNFPA-VN/IOIT, version 1.0). During the vectorization process, vectors (lines) were created from the various elements of the distribution maps, as shown in Fig. 2b. For georeferencing at least six characteristic locations on the distribution maps were chosen and given their respective geographic coordinates. For example, the coordinates 31,30 and -22,42 represent the intersection of the South African, Zimbabwean and Mozambican boarders near Pafúri. Based on this information, the coordinates of all other location on the vectorized map was computed by the programme. The georeferenced vectors of the distribution maps were exported as a shape-files (polylines) in *.shp format (Fig. 3a).

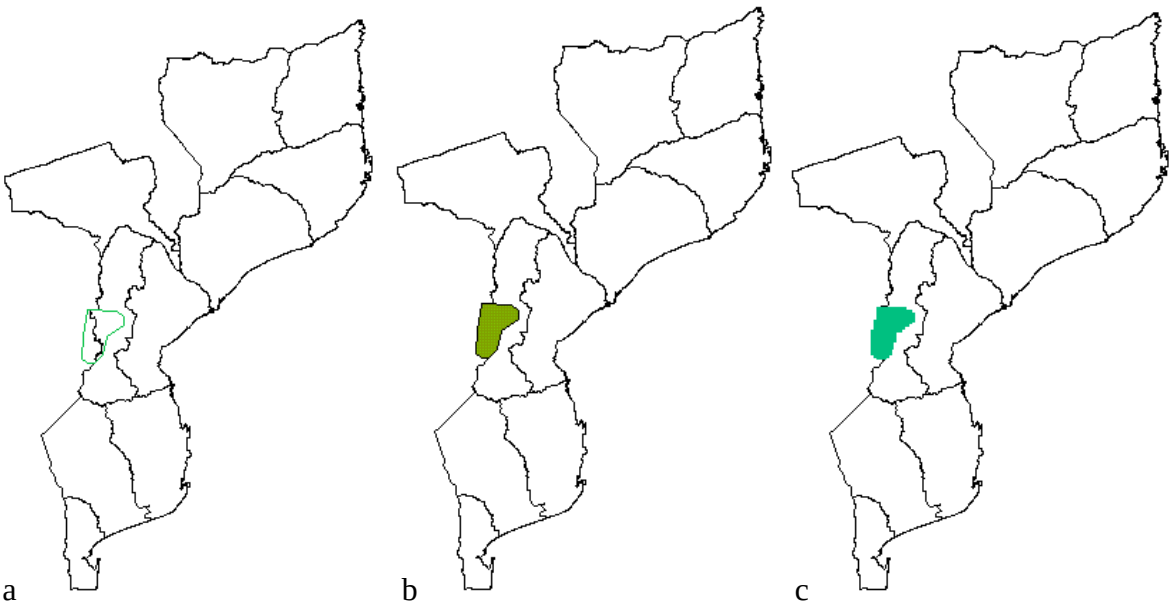


Figure 3 Example of a distribution map drawn in the format of a 'polyline' (a), 'polygon' (b) and 'grid' (c). Note that the political boundaries are not part of the polyline system.

Production of 'grids' and superposition of distribution maps

Based on the knowledge on a species' ecology, GIS allows the modelling of suitable areas within the species' distribution range (Area of Occupancy, AO) as well as the prediction of the probability of the species occurring in its AO (Scott *et al.*, 1993; Boitani *et al.*, 1999). In this study however, a more simple approach was used, only considering the Extent of Occurrence (EO), the classic presentation of the distribution range of a species.

Using the software ArcView GIS 3.2 (Environmental Systems Research Institute, Inc., USA, version 3.2), the 'polylines' resulting from the vectorization of distribution maps (Fig. 3a) were converted into 'polygons' (Fig. 3b). The value of '1' was attributed to the areas of occurrence of a certain species, the value '0' was given to areas outside of the range of occurrence.

In the following, these 'polygons' were used to produce 'grids' with a resolution of 250 x 365 squares with the dimensions of 8.5 km x 8.5 km (Fig. 3c). During the production of 'grids' the conversion fields with the previously defined cell values were picked. Finally, the 'grids' of certain species, e.g. of endemic mammals were chosen for the subsequent superposition, using the sub-programme MapCalculator of ArcView GIS 3.2. The programme calculates the sum of values of the superimposed squares (Fig. 4) that corresponds for instance with the number of endemic mammals occurring in the individual squares.

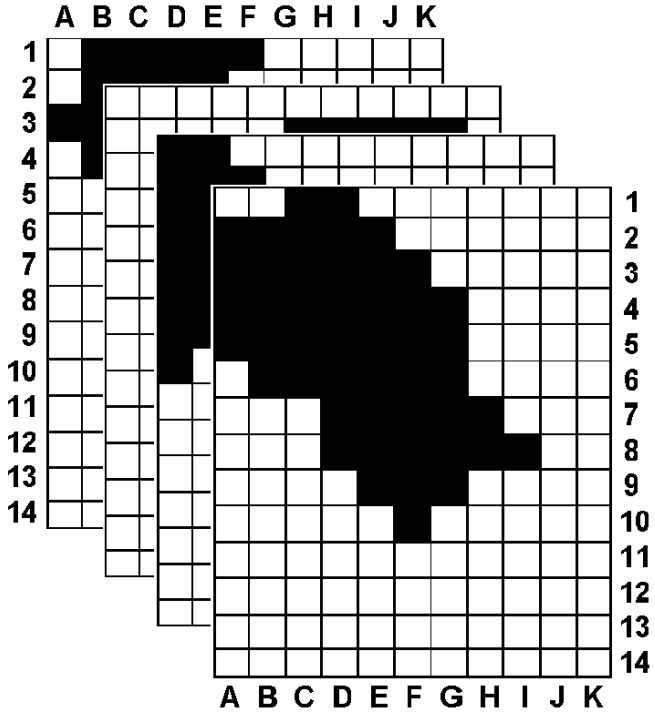


Figure 4 Superposition of 'grids' of the distribution areas of four hypothetical species: the value '1' was attributed to squares within the distribution area of a species (black squares), the value '0' to squares outside the species' distribution area (white squares). In the following, the sum of the values of square A1 of each species, of square A2 of each species, A3, ..., A14, B1, B2, ..., K12, K13 and K14 was calculated. The results of this example are A1 = 1, A2 = 2, A3 = 3, A4 = 2, ...

Assessment of representation of vertebrate 'hotspots' in the network of protected areas

The comparison of the identified centres of vertebrate diversity with the distribution of National Parks, Reserves and hunting areas of Mozambique showed if the identified 'hotspots' were represented in the network of protected areas. This allowed the identification of important areas that are sub-represented in the network of protected areas and permitted the identification of additional new protected areas.

RESULTS & DISCUSSION

Vertebrate diversity in Mozambique

Table 2 shows the summary of vertebrate diversity in Mozambique. According to the checklist of vertebrates (see Appendix) 3470 vertebrate species occur in Mozambique, of which 271 (7.8%) are mammals, 816 (23.5%) birds, 280 (8.0%) reptiles, 84 (2.4%) amphibians and 2019 (58,2%) species are fish. 503 vertebrate species are considered as threatened by extinction and protected by national and international legislation, i.e. 38.7% of the mammal species, 36.0% of birds, 11.8% of reptiles, 3.6% of amphibians and 3.4% of the fish species. 234 vertebrate species are endemic or near endemic to Mozambique, i.e. 7.7% of the mammal species, 14.1% of birds, 32.5% of reptiles, 2.4% of amphibians and 0.2% of the fish species. 20 vertebrate species were introduced into Mozambique, i.e. 3 (1.1%) mammal species, 3 (0.4%) birds, 1 (0.4%) reptile and 13 (0.6%) fish species.

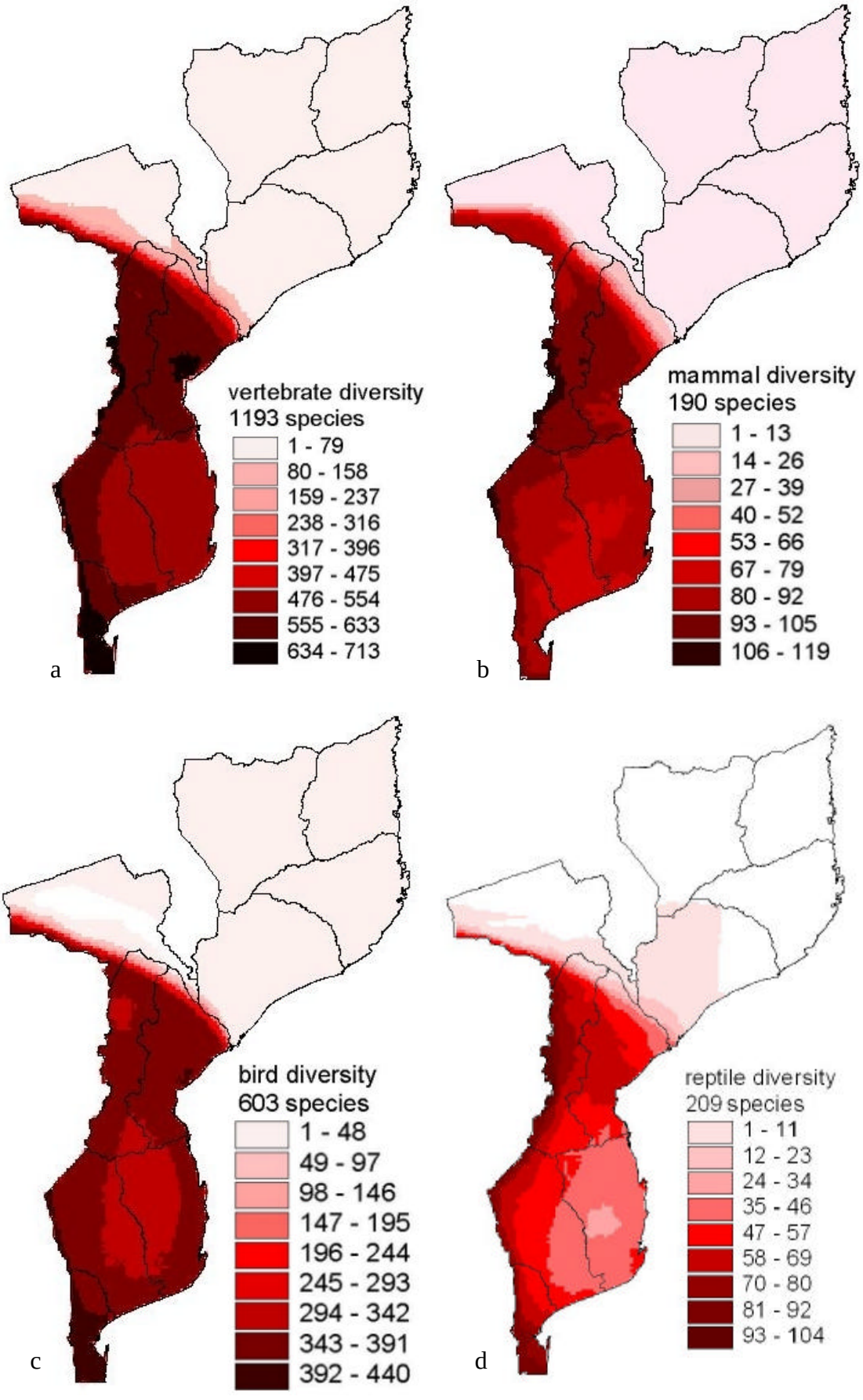
Table 2 Summary of vertebrate species of Mozambique

taxonomic group	total number of species (100%)	number and percentage of threatened and protected species	number and percentage of endemic or near endemic species	number and percentage of introduced species
mammals	271	105 (38.7%)	21 (7.7%)	3 (1.1%)
birds	816	294 (36.0%)	115 (14.1%)	3 (0.4%)
reptiles	280	33 (11.8%)	91 (32.5%)	1 (0.4%)
amphibians	84	3 (3.6%)	2 (2.4%)	no data
Fish	2019	68 (3.4%)	5 (0.2%)	13 (0.6%)
vertebrates	**3470**	**503 (14.5%)**	**234 (6.7%)**	**20 (0.6%)**

According to Smithers & Tello (1976), 227 mammal species can be found in Mozambique, out of which 216 species are terrestrial. Regarding birds, Lepage (2005) lists 742 species for Mozambique, including 20 threatened and two introduced species. According to MICOA (2003) 735 bird species occur in Mozambique, out of a total of about 900 species recorded in southern Africa (MacLean, 1985). MICOA (2003) estimates a total of 167 reptile species and Uetz (1998) lists 113 reptile species existing in Mozambique. In terms of amphibians, MICOA (2003) mentions 79 species and Frost (2000) lists 51 species for Mozambique. The ichthyofauna of Mozambique consists of 1742 fish species including four endemic, 90 threatened and protected and 13 introduced species (Froese & Pauly, 2004). According to Cumming (1999), Mozambique is the home of 179 species of mammals including 2 endemics, 666 species of birds, 170 species of reptiles including one endemic, 62 species of amphibians with two endemics and 500 species of fish out of which 400 are endemic.

Identification of terrestrial vertebrate 'hotspots' of Mozambique

The distribution of terrestrial vertebrates in Mozambique (Fig. 5a) shows areas with high diversity in the mountains of Chimanimani in Manica Province, along the Lebombo mountains in Gaza and Maputo Provinces and in the south of Maputo Province. The mammal diversity (Fig. 5b) is high in Sofala e Manica Provinces, particularly along the mountains of Chimanimani and in the east of Gaza Province. The distribution of bird species (Fig. 5c) south of the Zambeze River is more or less uniform, with slightly elevated density in the south of Maputo Province and lower density in Gaza and Inhambane Provinces. Reptile distribution (Fig. 5d) shows higher diversity in the mountains of Chimanimani and along the Lebombo mountains in Gaza and Maputo Provinces. Other diversity 'hotspots' of reptiles can be found in the east of the Great Inselberg Archipelago in Zambézia Province, in Bazaruto and Inhambane Archipelagos, along the coast of Gaza and Maputo Provinces and in the centre of Sofala Province. Amphibian diversity (Fig. 5e) is high in the centres of Manica and Sofala Provinces, in the south Maputo Province and near Mount Chiperone in the east of the Great Inselberg Archipelago in Zambézia Province. The big rivers of Mozambique are particularly rich in freshwater fish species, e.g. the Zambeze and Pungué Rivers in Zambézia, Sofala and Tete Provinces, coastal Inhambane and Gaza Provinces as well as the river systems in the south of Mozambique like Limpopo and Incomáti Rivers (Fig. 5f).


vertebrate diversity
1193 species
1 - 79
80 - 158
159 - 237
238 - 316
317 - 396
397 - 475
476 - 554
555 - 633
634 - 713
a
mammal diversity
190 species
1 - 13
14 - 26
27 - 39
40 - 52
53 - 66
67 - 79
80 - 92
93 - 105
106 - 119
b
bird diversity
603 species
1 - 48
49 - 97
98 - 146
147 - 195
196 - 244
245 - 293
294 - 342
343 - 391
392 - 440
c
reptile diversity
209 species
1 - 11
12 - 23
24 - 34
35 - 46
47 - 57
58 - 69
70 - 80
81 - 92
93 - 104
d

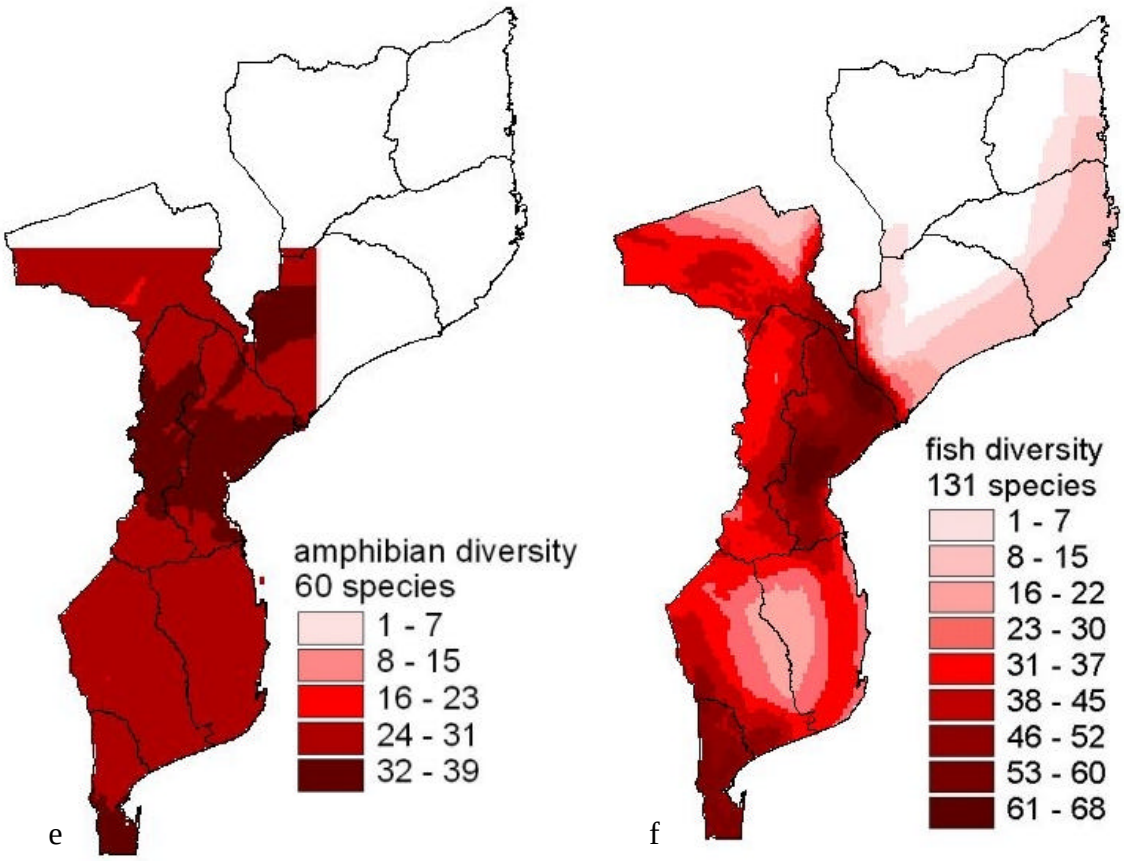


Figure 5 'Hotspots' of terrestrial vertebrate (a), mammal (b), bird (c), reptile (d), amphibian (e) and fish diversity (f) in Mozambique

The centres of endemic or near endemic terrestrial vertebrates (Fig. 6a) can be found in the mountains of Chimanimani in Manica Province, in the area of Gorongosa and in the centre of Sofala Province, along the Lebombo mountains in Gaza and Maputo Provinces, south of the Inhambane Archipelago and in the region of Panda in Inhambane Province, in the east, centre and south of Gaza Province and in Maputo Province. Endemic mammal species are concentrated in the region of Mount Gorongosa - Rift Valley - Marromeu Complex, in the Chimanimani mountains, along the coast of the southern Provinces, particularly between Vilanculos and Inhambane as well as south of Save River near Inhassoro and Zinave (Fig. 6b). Endemic bird species occur in high density in the centre of Sofala Province, in Chimanimani mountains in Manica Province, along Lebombo mountains in Gaza and Maputo Provinces, in the south of Inhambane Province, particularly between Panda and Inhambane Archipelago and in Maputo Province (Fig. 6c). 'Hotspots' of endemic reptiles were identified in the region of Chimanimani mountains, along the Lebombo mountains in Gaza and Maputo Provinces, particularly in the Pafúri region, Bazaruto and Inhambane Archipelagos, the coast of Gaza and Maputo Provinces and in the Districts of Moamba, Boane and Matutuíne (Fig. 6d). Due to a lack of data, the situation of amphibians and fish could not be assessed sufficiently, but according to Skelton (2001), 61% of the species of freshwater fish of southern Africa are endemic, e.g. 4% of the species of Limpopo River and 17% out of the 134 species occurring in Zambeze River are endemic.

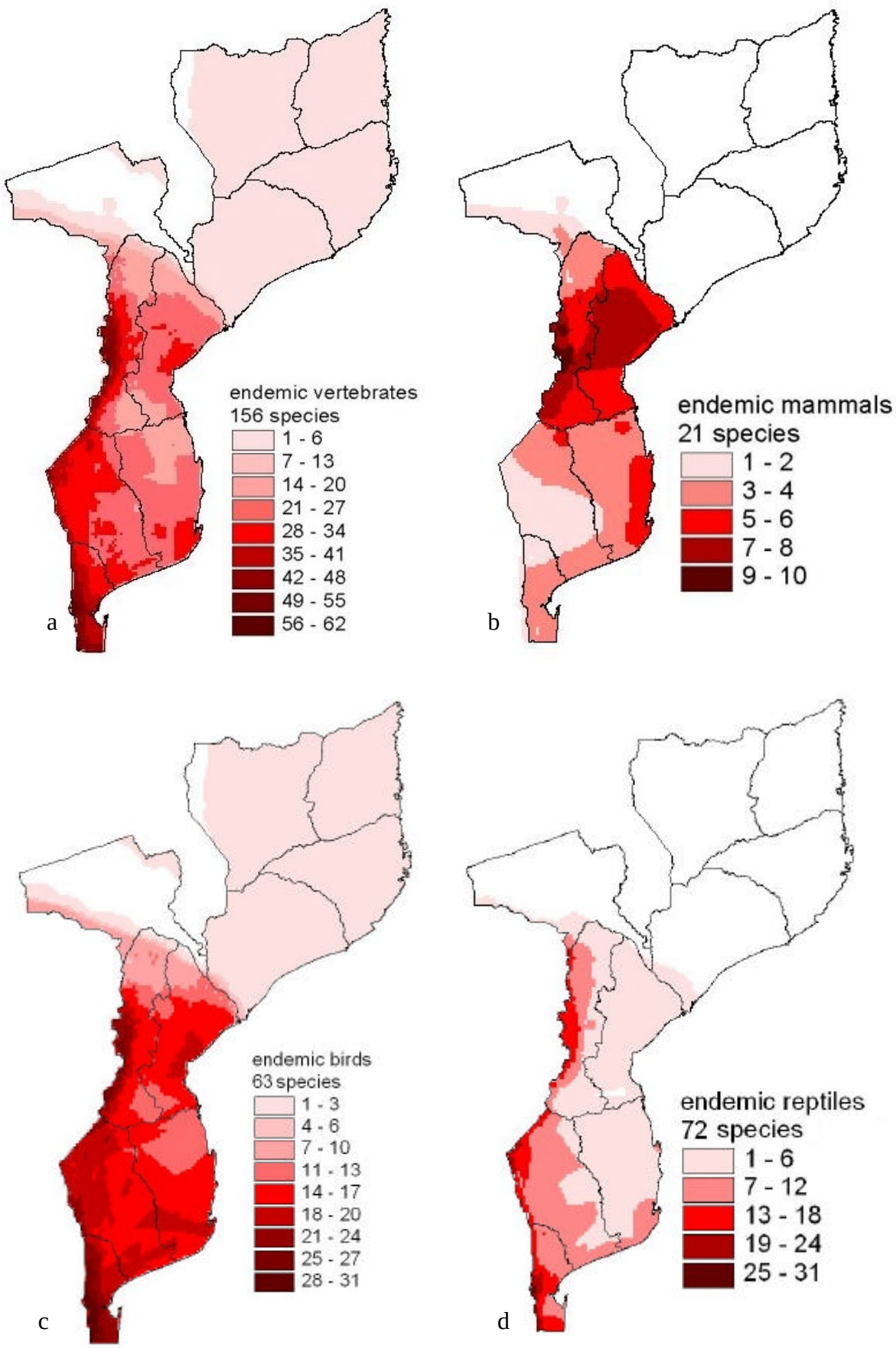
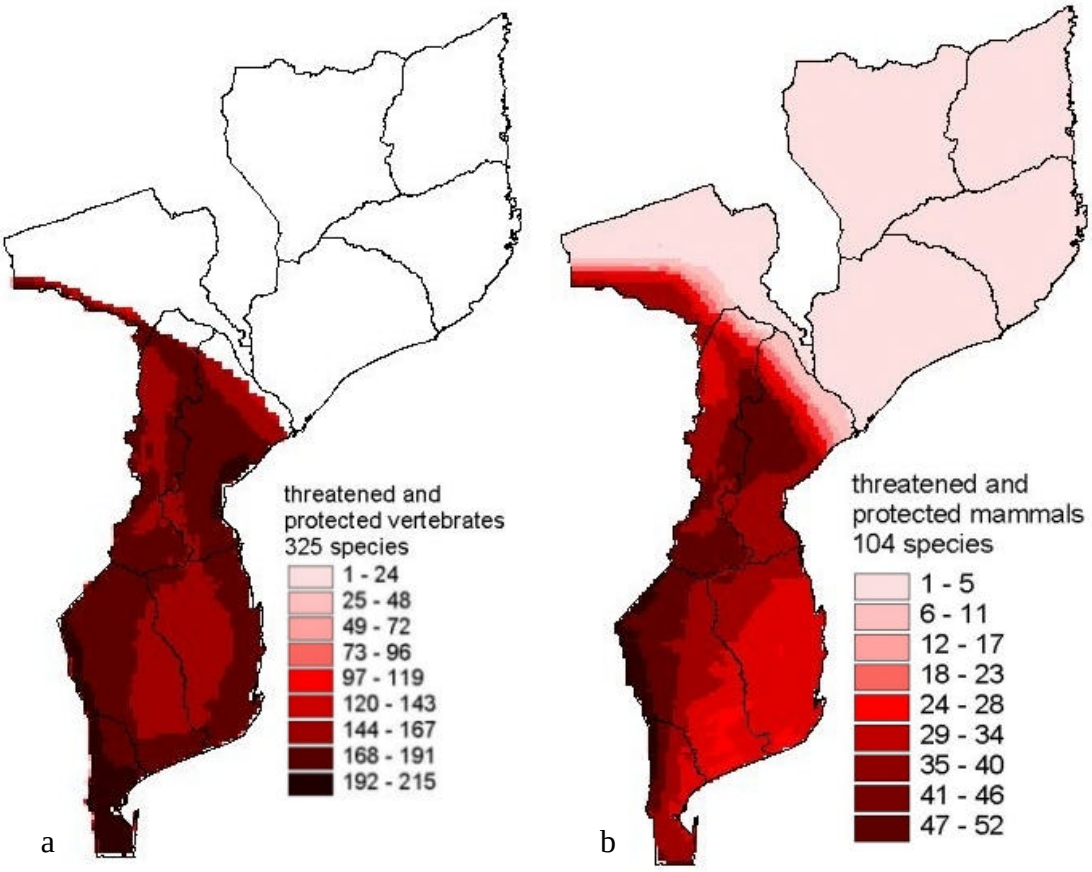


Figure 6 'Hotspots' of endemic or near endemic terrestrial vertebrate (a), mammal (b), bird (c) and reptile species (d) in Mozambique

Threatened and protected terrestrial vertebrates (Fig. 7a) and birds (Fig. 7c) show high diversity south of Zambeze River, particularly in the centre o Sofala Province, along the Lebombo mountains in Gaza and Maputo Provinces and in the west of Sofala Province. The distribution of threatened and protected mammals (Fig. 7b) is similar, but there is a lower species diversity along the coast of Inhambane, Gaza e Maputo Provinces. Threatened and protected reptiles (Fig. 7d) are concentrated in Sofala and Manica Provinces, particularly in the Chimanimani mountains, the Lebombo mountains in Gaza and Maputo Provinces and in the south of Maputo Province. No data were available on threatened and protected amphibians. Regarding freshwater fish, threatened and protected species (Fig. 7e) occur all along the coast of Mozambique and in the major rivers such as Zambeze, Pungué, Buzi and Save Rivers and with higher densities in the Limpopo and Incomáti river systems.

The distribution of threatened and protected freshwater fish seems to be related with high densities of humans. Anthropogenic factors such as overfishing, pollution and introduction of alien species could threaten these species. This fact should be further elucidated in order to mitigate the situation and avoid local extinction of certain species in the future.



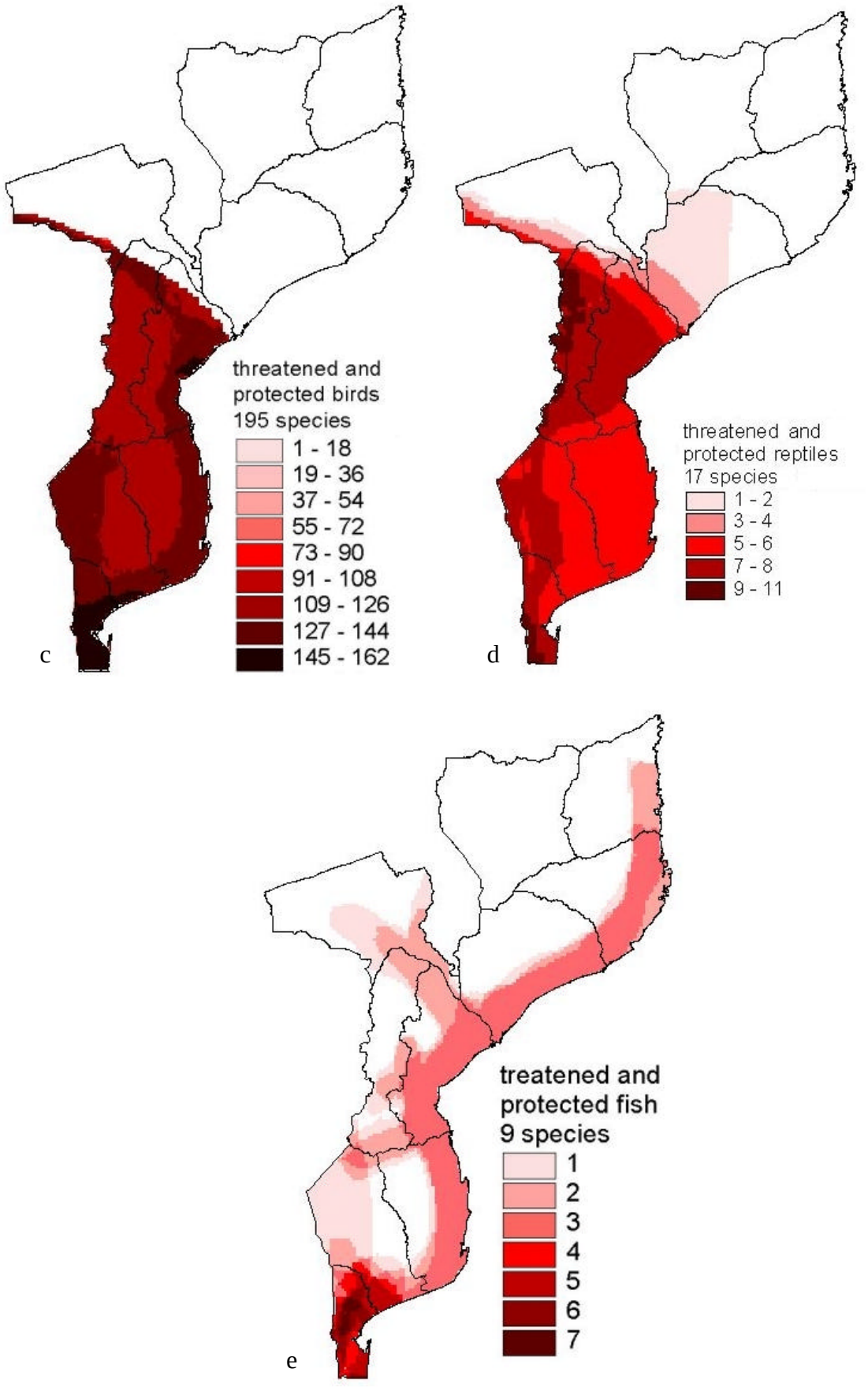


Figure 7 'Hotspots' of threatened and protected terrestrial vertebrate (a), mammal (b), bird (c), reptile (d) and fish species (e) in Mozambique

Species distribution in a country's territory usually is not uniform but shows species aggregation in certain centres (Csuti & Crist, 2000). Generally, centres of diversity as well as 'hotspots' of endemic, threatened and protected vertebrates of Mozambique can be found in (i) the region of Mount Gorongosa - Rift Valley - Marromeu Complex in Sofala and Manica Provinces, (ii) the region of Chimanimani mountains in Manica Province, (iii) along the Lebombo mountains in Gaza and Maputo Provinces, (iv) along the coast of Inhambane, Gaza and Maputo Provinces and (v) in the Mozambican part of Maputaland in the south of Maputo Province. A comparison of the distribution of vertebrate species with the distribution of endemic trees and trees with isolated populations (Fig. 8a) shows similar spatial concentration.

The region of Mount Gorongosa - Rift Valley - Marromeu Complex is well known for its richness in forests and consequently in vertebrate species (e.g. Dutton & Dutton, 1973; Werger, 1978; MICOA, 2003). According to Werger (1978), the particular geography of this region favours high biodiversity as well as a high degree of endemism. Mount Gorongosa, being the only elevation in the area, is characterized by humid winds resulting in annual precipitations of over 2000 mm. The Cheringoma Plains, a depression between the Zambeze and Pungué Rivers rich in alluvial sediments, are the southernmost extension of the Great Rift Valley. The wetlands between Beira and Marromeu south of the Zambeze River estuary with extensive mangroves and grasslands are particularly diverse in migratory avifauna, ichthyofauna and other aquatic life forms.

The Chimanimani Massif along the Mozambican-Zimbabwean boarder constitutes the major eastern slope of the central-south African Plateau (Dutton & Dutton, 1973; MICOA, 2003). The Chimanimani mountains, one of the afro-mountainous regions of Mozambique, have been assigned high diversity of rare and endemic animal and plant species, habitats and ecosystems with unique character in Mozambique (Dutton & Dutton, 1973).

The Lebombo mountains along the boarder with South Africa and Swaziland are characterized by elevated precipitation between 1000 to 1200 mm annually, clay soils and alluvial sediments. The high humidity, the typically fresh climate and the rivers passing through this region favour high diversity of various taxonomic groups of vertebrates (Werger, 1978; MICOA, 2003). The most southern area of the Lebombo mountains with its deep gorges and diverse rock formations is part of the Maputaland region. These conditions favour elevated vertebrate diversity as well as high degree of endemism (Smithers & Tello, 1976).

As shown by this study and by other authors (Werger, 1978; MICOA, 2003), the fauna of the Maputaland - Pondoland region is particularly diverse. According to MICOA (2003), out of the more then 470 species of birds 47 are endemic or near endemic. 14 out of the 102 mammal species, 23 out of the 112 reptile species, 3 out of the 45 amphibian species and 7 out of the 67 species of fresh water fish are endemic. Due to the high floristic complexity and diversity of the region, van Wyk (1994) proposed the creation of a centre of endemism in the Maputaland - Pondoland region, including the south of Mozambique.

The coastal areas in Gaza, Inhambane and Maputo Provinces also show elevated diversity and endemism of certain taxonomic groups of vertebrates. Particularly the Bazaruto and Inhambane Archipelagos are rich in endemic mammals, birds and reptiles, probably due to the isolation of the islands. According to MICOA (2003), the dugong, a species considered as seriously threatened of extinction, has one of its major populations of Mozambique in the littoral waters of the Bazaruto Archipelago and other smaller populations in the Inhambane Archipelago. The low diversity of vertebrates in the hinterlands of Gaza and Inhambane Provinces are probably due to the arid conditions of these areas.

North of the Zambeze River, the area of the Great Inselberg Archipelago in Zambézia and Nampula Provinces are well known for their high biodiversity and degree of endemism

(@@@; MICOA, 2003). Species richness is particularly high on Mount Chiperone and Mount Namúli due to their altitude, exposing them high above the surrounding lowland plains, due to the resulting high precipitation and the isolation of the individual inselbergs.

According to this study, the species richness of vertebrates appears to be much lower in the north of the Zambeze River. This is generally due to the unavailability of data on occurrence and distribution of these species. In the case of mammals and amphibians the distribution data for the north of Mozambique (Smithers & Tello, 1976; Channing, 2001) were not compatible with the used methodology.

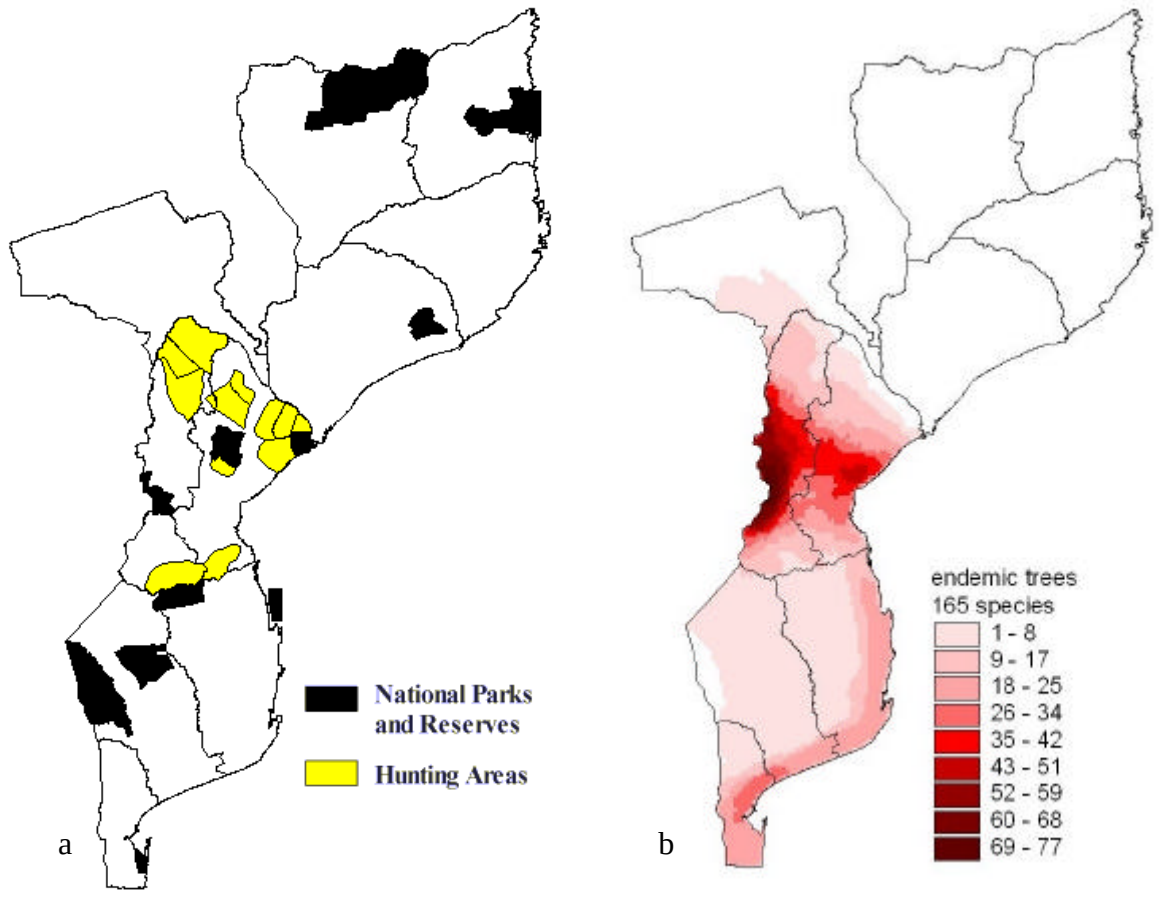


Figure 8 'Hotspots' of endemic trees and tree species with isolated populations (a) and network of National Parks, Reserves and Hunting Areas of Mozambique (b) [taken from Aliasse, 2004]

Representation of 'hotspots' of vertebrate diversity in the network of protected areas

The comparison of Figs. 5, 6 and 7 with Fig. 8b shows that some centres of diversity, endemism and threats are not well represented in the existing network of National Parks, Reserves and hunting areas of Mozambique. Areas outside of this network are (i) the mountains in the north of the Chimanimani National Reserve in Manica Province, (ii) the coastal area north of Beira in Sofala Province, (iii) the coastal areas of Inhambane, Gaza e Maputo Provinces, (iv) the region of Panda in Inhambane Province as well as (v) the Great Inselberg Archipelago in Zambézia and Nampula Provinces including Mount Chiperone and Mount Namúli. This subrepresentation of conservation 'hotspots' in the protected areas

network can affect the efficiency of *in situ* conservation of these species and of other elements of biodiversity (Walkey *et al*., 1999).

Mozambique has a remarkable network of National Parks and Reserves of about 83.386 km^2, equivalent to 10.4% of its territory (MICOA, 2003). Fig. 8b shows the distribution of these protected areas including official hunting areas. It is noteworthy that Tete and Nampula Provinces do not have this kind of protected areas. The concentration of protected areas in Manica and Sofala Provinces coincides with the 'hotspots' of vertebrate diversity identified in this study. However, the boundaries of some of the existing protected areas like Gorongosa National Park, do not correspond with the ecological boundaries of the respective area.

CONCLUSION & RECOMMENDATIONS

This study revealed the occurrence of 3470 species of vertebrates in Mozambique, i.e. 271 mammals, 816 birds, 280 reptiles, 84 amphibians and 2019 fish species. 234 are endemic or near endemic species and 503 species of vertebrates are threatened by extinction and protected by Mozambican and international legislation. 20 species of vertebrates were introduced into the territory of Mozambique.

The regions with high terrestrial vertebrate diversity and rich in endemic, threatened and protected species in Mozambique are:

- Mount Gorongosa - Rift Valley - Marromeu Complex in Sofala and Manica Provinces,
- the mountains of the Chimanimani region in Manica Province,
- the Lebombo mountain range in Gaza and Maputo Provinces,
- the coast of Inhambane, Gaza and Maputo Provinces,
- the Mozambican part of Maputaland region in the south of Maputo Province and
- the Great Inselberg Archipelago in Zambézia and Nampula Provinces including Mount Chiperone and Mount Namúli.

The network of National Parks and Reserves of Mozambique covers 10.4% of the total area. Underrepresented in this network are the following 'hotspots' of vertebrate diversity, endemism and threats:

- the mountains in the north of the Chimanimani National Reserve in Manica Province,
- the coastal area north of Beira in Sofala Province,
- the coastal areas of Inhambane, Gaza e Maputo Provinces,
- the region of Panda in Inhambane Province as well as
- the Great Inselberg Archipelago in Zambézia and Nampula Provinces.

This under-representation in the network of protected areas can affect the efficiency of *in situ* conservation of these species and of other elements of biodiversity. Therefore it is recommended:

- a redefinition of the boundaries of existing protected areas and/or the proclamation of additional protected areas or other measures to increase the representation of the identified 'hotspots' in the network of protected areas to allow a more efficient *in situ* conservation of vertebrates,

- the realization of fauna surveys in Tete, Zambézia, Nampula, Cabo-Delgado and Niassa Provinces to assess the occurrence and distribution of vertebrate species,
- the establishment of a central database with information on the distribution of vertebrate species, the abundance of the important species, threats of extinction and other relevant information. The database could be jointly maintained by the National Directorate of Forests and Wildlife (DNFFB), National Directorate of Conservation Areas (DNAC), Ministry of Environment (MICOA), FAO, The World Conservation Union (IUNC), WWF, universities and other relevant entities with the aim to facilitate the sustainable use of wildlife resources, determination of hunting quotas, research, management of protected areas and identification of threatened species. The data provided by this study could serve as a starting point for the elaboration of such a database.

ACKNOWLEDGEMENTS

The authors appreciate the kind assistance of Dr. Augusto Cabral, Director of Natural History Museum, Maputo in the translations of the common names into Portuguese and are grateful to The World Conservation Union (IUCN) Mozambique for funding the study through Fundo para a Gestão dos Recursos Naturais e Ambiente (FGRNA), Project No. 17/2004/FGRNA/PES/C2CICLO2.

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