Vertebrate distributions indicate a greater Maputaland-Pondoland-Albany region of endemism

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The Maputaland-Pondoland-Albany (MPA) biodiversity hotspot (~274 316 km^2) was primarily recognised based on its high plant endemism. Here we present the results of a qualitative biogeographical study of the endemic vertebrate fauna of south-eastern Africa, in an exercise that (1) refines the delimitation of the MPA hotspot, (2) defines zoogeographical units and (3) identifies areas of vertebrate endemism. Initially we listed 62 vertebrate species endemic and 60 near endemic to the MPA hotspot, updating previous checklists. Then the distributions of 495 vertebrate taxa endemic to south-eastern Africa were reviewed and 23 endemic vertebrate distributions (EVDs: distribution ranges congruent across several endemic vertebrate taxa) were recognised, amongst which the most frequently encountered were located in the Eastern Escarpment, central KwaZulu-Natal, Drakensberg and Maputaland. The geographical patterns illustrated by the EVDs suggest that an expansion of the hotspot to incorporate sections of the Great Escarpment from the Amatola-Winterberg-Sneeuberg Mountains through the Drakensberg to the Soutpansberg would be justified. This redefinition gives rise to a Greater Maputaland-Pondoland-Albany (GMPA) region of vertebrate endemism adding 135% more endemics with an increase of only 73% in surface area to the MPA hotspot. The GMPA region has a more natural boundary in terms of EVDs as well as vegetation units. An accurate delimitation of this hotspot, as well as a better understanding of biogeography in the region, would greatly benefit conservation planning and implementation. Towards these aims, we used EVDs to delimit non-overlapping zoogeographical units (including 14 areas of vertebrate endemism), facilitating numerical biogeographical analyses. More importantly, this study opens up possibilities of refining hotspot delimitation and identifying local conservation priorities in regions of the world where data do not allow numerical analyses.

Introduction

Despite criticism over their selection and delimitation, biodiversity hotspots[1,2] have undeniably become a popular approach for prioritising conservation efforts globally,[3] as well as in South Africa.[4] Of the 34 global biodiversity hotspots, 3 are either within South Africa or extend marginally into neighbouring countries: the Cape Floristic Region, the Succulent Karoo and the Maputaland-Pondoland-Albany (MPA). In a broader context, southern Africa, defined as the area south of the Cunene, Okavango and Zambezi Rivers,[5] fully encompasses these three hotspots together with the southern parts of the Coastal Forests of Eastern Africa hotspot.[1] The major biological criterion for the designation of biodiversity hotspots is floristic endemism, that is, the area must contain at least 0.5% of the world's vascular plant species (1500 species) as endemics.[1,2] This means that animal endemism *per se* is not critical for hotspot selection, although vertebrates are most likely to become hotspot flagship species.[6]

The MPA biodiversity hotspot stretches along the eastern coast of southern Africa from Maputo in the north-east to Port Elizabeth in the south-west, extending inland towards the Great Escarpment.[7] In compliance with the criteria for defining biodiversity hotspots, it is an important centre of plant endemism, being home to 1900 endemic species.[5,7] The delimitation of floristic regions by White[8] and van Wyk and Smith[5] provided the basis for the original recognition of this hotspot. White's Tongaland-Pondoland regional mosaic has been extended further inland by van Wyk and Smith[5] as the Maputaland-Pondoland region of floristic endemism, to include the Afromontane elements below 1800 m a.s.l. along the Great Escarpment. In delimiting the MPA hotspot, Mittermeier et al.[2] followed the suggestion of van Wyk and Smith[5] and extended the Maputaland-Pondoland region in a south-westerly direction to the Albany centre, giving rise to a hotspot encompassing all three centres (Maputaland, Pondoland and Albany). Nevertheless, the hotspot has not yet been well documented in terms of its animal endemism, except for the species accounts given by Mittermeier et al.[2], those in the terrestrial vertebrate species database of Conservation International[9] and in the draft ecosystem profile of the hotspot.[10]

Even though the vertebrate fauna of southern Africa is relatively well studied, greater emphasis on vascular plants (with 60% species endemism)[5] and perhaps on large widespread mammals

has overshadowed the broader picture of southern African vertebrate endemism (especially with regard to smaller vertebrates) in the scientific literature. A relatively strong correlation in global endemism patterns has been observed between plants and vertebrates,[11] although the congruence is not always high at regional scales (e.g. eastern Madagascar[12] and the Cape Floristic Region[13]). In the tropical forest hotspots of Africa (i.e. the Eastern Arc and the Coastal Forests of Eastern Africa), the patterns of plant endemism are matched by those of vertebrates, but this congruence is lower in the Cape Floristic Region, which has a Mediterranean-type climate.[1] It is yet to be tested whether the floristic endemism in south-eastern Africa, ranging from subtropical to temperate latitudes, will show congruence with patterns of vertebrate endemism.

Early phytogeographical studies of Africa have used intuitive chorological approaches to delimit floristic regions (phytochoria) and centres of floristic endemism,[5,8] and recent studies have tested their validity using multivariate cluster analyses.[14,15,16] In turn, vertebrate biogeography has addressed patterns in different vertebrate classes across Africa, initially by grouping species ranges qualitatively through visual sorting and matching,[17,18] and later by numerical cluster analyses on distribution data.[19,20,21,22,23,24,25] However, the databases used for most of the numerical analyses were incomplete and/or biased because various subjective factors were involved as a result of the lack of uniform sampling throughout the study areas. All these analyses were based on distribution patterns of taxa in single vertebrate classes (frogs,[17,18,23,25] large mammals[22] and birds[19,20,21,24]). Crowe[26] summarised faunal zones for several terrestrial vertebrate groups through numerical analyses, but used larger and different grid quadrats (~110 km × 110 km for water birds, ~220 km × 220 km for frogs, snakes and lizards, and ~400 km × 400 km for larger mammals and terrestrial birds), which may have been too coarse to pick up patterns of narrow endemism. No attempt has yet been made to delimit zoogeographical units or areas of endemism for the entire vertebrate fauna of southern Africa.

Therefore, this paper documents vertebrate diversity and endemism in the MPA hotspot as currently defined, using the latest available literature. Subsequently, distribution ranges that are congruent across several endemic vertebrate taxa in south-eastern Africa are identified and used (1) to discuss the adequacy of the current boundary of the MPA hotspot, and (2) to propose a set of non-overlapping geographical units for a rigorous numerical analysis of south-east African zoo-(bio-) geography. The results we present here are not based on any numerical analysis, and as such our methods can be replicated in regions of the world where data are scarce.

Methods

Study area

This paper focuses on south-eastern Africa, delimited in the west by the Nelspoort interval in the southern Great Escarpment[27,28] (about 24° E), and in the north by the northernmost loop of the Limpopo valley (about 22° S). The study area fully encompassed the MPA hotspot[7] and the Maputaland, Pondoland, Albany, Drakensberg, Barberton, Wolkberg, Sekhukhuneland and Soutpansberg centres of floristic endemism,[5] together with the Highveld and Bushveld bioregions,[29] to the west and north-west of the MPA, respectively, and the Lowveld and Mopane bioregions[29] in the north-east.

Assessment of vertebrate endemism

Vertebrate species richness and endemism within the MPA hotspot, and endemism only for south-eastern Africa, were assessed based on distribution data available in the literature. We used the latest available atlases as the primary sources of data for amphibians, reptiles and birds (with data at quarter degree square[30] scale, hereafter QDS), supplemented with other data where QDS data were not available. The use of data other than atlases is of particular importance (1) as sources of distribution data beyond the atlas regions of 'South Africa, Lesotho and Swaziland' for the herpetofauna, (2) to assess their endemicity in south-eastern Africa (see below for our definition of south-east African endemism) and (3) to assess whether the atlas records are of breeding populations or migrants in the case of birds. Freshwater fish distributions were sourced from Skelton[31,32] and further validated using *FishBase* (Froese and Pauly[33]). The amphibian atlas of Minter et al.[34], mirrored by the online Virtual Museum of the Animal Demography Unit, University of Cape Town, was supplemented with data from du Preez and Carruthers[35] and similarly the reptile atlas of the Southern African Reptile Conservation Assessment, available online (Animal Demography Unit[36]) was supplemented with data from Branch[37]. The original bird atlas of Harrison et al.[38], and updated atlas-based maps in Hockey et al.[39] were used as sources of bird data, whilst the comprehensive treatment by Skinner and Chimimba[40] was used for mammals, as the mammal data in the online Virtual Museum of the Animal Demography Unit is as yet far from complete. Museum databases were not considered in the cases of freshwater fish and mammals, as they are particularly incomplete and collection biases are prominent, especially in freshwater fish. Species taxonomy follows the latest treatment mentioned above for each taxon, that is Froese and Pauly[33] for freshwater fish, du Preez and Carruthers[35] for amphibians, Animal Demography Unit[36] (as at 31 January 2010) for reptiles, updated following Kelly et al[41] for the family Lamprophiidae, Hockey et al.[39] for birds, and Skinner and Chimimba[40] for mammals, whilst other sources[42,43,44] were used in updating familial-level taxonomy.

Vertebrate species richness and endemism in the MPA hotspot

We compiled checklists of vertebrate species for the MPA hotspot as currently defined, updated those available in the terrestrial vertebrate species database of Conservation International,[9] and produced a first checklist of freshwater fish species for the region. The list also includes the secondary freshwater species (coastal/estuarine species that also occur in fresh water, excluding the stragglers or sporadic marine fishes that are sometimes found living, but not breeding, in inland waters[31]). Besides endemic species, near-endemic species were also listed for the hotspot, as they are important

in recognising biogeographical links between the hotspot and surrounding regions. MPA near endemics were defined as those species with more than 50% of their range within the hotspot, and extending outside the hotspot only marginally (e.g. bush blackcap, *Lioptilus nigricapillus* and Natal red rock rabbit, *Pronolagus crassicaudatus*) and/or with small distant satellite populations outside it (e.g. Natal mountain catfish, *Amphilius natalensis*; Phongolo suckermouth, *Chiloglanis emarginatus*; and laminate vlei rat, *Otomys laminatus*). In order to minimise subjectivity in including or excluding marginal species, those that occurred along the boundary of the hotspot were included only if they showed a prominent association with habitat types that occur within the hotspot.

Vertebrate taxa endemic to south-eastern Africa

In order to correct for possible errors induced by having a latitude-longitude boundary for the study area when dealing with natural distribution ranges, we defined south-east African endemics as taxa with more than 50% of their extent of occurrence (at the QDS scale when data were available and approximately elsewhere) south of 22˚S and east of 24˚E. Therefore, even the taxa that cross 22˚S and 24˚E latitude-longitude boundaries were included in the analysis, as long as they were endemic to south-eastern Africa in a broader sense, and met the above criterion. Taxa endemic to the Cape Floristic Region and the Coastal Forests of Eastern Africa hotspots were excluded.

A database was compiled comprising all taxa endemic to south-eastern Africa. Taxa referred to here are species, whilst infraspecific taxa (subspecies, subspecies complexes and populations) were also taken into account wherever there was a considerable geographical disjunction. More specifically, a disjunct subspecies or subspecies complex isolated by a gap of more than one degree (~100 km) or a disjunct population (not recognised as a subspecies) isolated by a gap of more than 2 degrees (~200 km) or (in the case of freshwater fish) when found occurring in different major river systems that were not in contact under current drainage patterns, were included as a separate taxa. An exception was made for subspecies of range-restricted species endemic to south-eastern Africa, where subspecies were accepted as disjunct with a gap of more than 50 km.

The extent of occurrence of a given taxon was determined using records of naturally occurring breeding populations, excluding migrant and vagrant records as well as introduced (deliberately or unintentionally) and relocated populations extralimital to their natural range. Marine taxa were excluded from the analysis. The separation of terrestrial and freshwater taxa from marine taxa was self-explanatory in the case of marine mammals, pelagic sea birds and marine reptiles. In the case of fish, all taxa listed by Skelton[31] as freshwater or secondary freshwater taxa were considered. Any ambiguity in taxonomy or distribution, and difficulties in delimiting range boundaries (e.g. because of recent taxonomic revisions or single historical records not verified by recent extensive surveys) resulted in disqualifying the taxon or a particular record. The undescribed species listed by the Animal Demography Unit[36] and du Preez and Carruthers[35] were included when distribution data were provided and matched our criteria.

Precautions were taken when plotting bird distributions to minimise the bias caused by their higher dispersal ability compared to other vertebrates. Therefore, single outlying occupied QDSs were considered to be part of a taxon's extent of occurrence only if the reporting rate was more than 2% (see methods in Harrison et al.[38]). Single outlying occupied QDSs more than 200 km away from core populations were omitted from the extent of occurrence, and not considered as isolated populations. Isolated records/subpopulations of bird species that were widely but sparsely distributed, especially in the case of aquatic birds (e.g. spotted crake, *Porzana pusilla* and lesser jacana, *Microparra capensis*) were not regarded as disjunct. Bats (Order Chiroptera) were treated only at the species level, considering isolated records as parts of a single scattered population because they are long-distance flyers that are not easily detected and hence may have been overlooked. Disjunct populations of small mammals were also disregarded when disjunctions were likely to be the result of insufficient observations.

Identification of endemic vertebrate distributions

Distribution ranges that are congruent across several endemic vertebrate taxa are defined as endemic vertebrate distributions (EVDs). They often overlap each other, and hence cannot be used as exclusive biogeographical units, or considered for a hierarchical geographical analysis, but serve here as a first step in the qualitative grouping of distribution ranges. The EVDs were used in (1) identifying spatial relationships amongst endemic vertebrate assemblages, in an effort to refine the delimitation of the MPA hotspot and (2) delimiting non-overlapping geographical units for a hierarchical biogeographical analysis.

EVDs were detected through an extensive review of the distribution data followed by plotting, visual sorting and matching of distribution ranges. This qualitative method was developed based on the classical biogeographical methods of White[8] and van Wyk and Smith[5] for the flora, and Poynton[17,18] for amphibians. The subjectivity of the results obtained through this method can be reduced with wider experience, a critical outlook and possession of a good eye and memory.[45] Whilst White[45] emphasises the importance of subsequent rigorous analysis for intuitively defined biogeographical regions, subsequent analytical confirmations of such regions (e.g. Linder[14] and Linder et al.[15] for White's[8] phytochoria of Africa; Procheş[46] and Kreft and Jetz[47] for Wallace's[48] zoographical regions of the world) have added credibility to such methods. Where our study area is concerned, even though Poynton's[18] intuitively defined regions of amphibian biogeography are not exactly matched by those identified in the subsequent numerical analysis of Alexander et al.[25], the general biogeographical patterns were largely congruent. Further to that, it has been noted[49] that the frog atlas[34] representing the database for Alexander et al.[25] has some serious sampling biases and is of limited use for fine-scale analysis. Alexander et al.[25] themselves accepted this as a fact, using half-degree squares for their analysis, whilst the atlas provides data at the QDS scale. Thus, the discrepancies between Poynton's[18] and Alexander et al.'s[25] results may be attributed to data-related limitations, rather than to different methods.

Once the EVDs were delimited, every taxon selected for the study was then assigned to the narrowest of the EVDs encompassing all of its accepted breeding records, to assess the frequency of occupation of each EVD. The EVDs were then used in refining the delimitation of the MPA hotspot.

Delimitation of zoogeographical units

A set of non-overlapping zoogeographical units was designed based on (1) the core regions of EVDs (delimited adopting Linder and Mann's[50] method of 'mapping individual species distributions and seeking areas of overlap for range restricted taxa'), (2) the overlapping margins of EVDs and (3) the patterns of narrower endemism within broader EVDs. When borders of adjacent units thus delimited did not align with each other, the coverage of relevant EVDs was taken into consideration, and the borders were further adjusted using the boundaries of biomes and bioregions.[29] Amongst the zoogeographical units delimited, those harbouring two or more narrow-range endemic vertebrate species characteristic of them were treated here as areas of vertebrate endemism (AOVEs), following Nelson and Platnick's[51] definition for 'areas of endemism'.

Results

Vertebrate species richness and endemism in the Maputaland-Pondoland-Albany biodiversity hotspot as currently defined

A list of 1217 regularly occurring indigenous species of vertebrates (representing 586 genera in 184 families), including 62 (5.1%) endemic and 60 (4.9%) near-endemic species is provided for the MPA hotspot (Table 1). In addition, at least 51 bird species were recorded from the hotspot as vagrants, and at least 25 alien species were introduced to the hotspot and have well-established populations. Birds show the highest species richness within the MPA hotspot (668 naturally occurring species including vagrants), whilst the herpetofauna show the highest endemism (21.3% in amphibians and 14.3% in reptiles). Endemic and near-endemic vertebrates of the MPA hotspot are listed in Appendix 1, whilst a complete checklist of all vertebrates occurring in the hotspot is available as online supplementary material to this paper (vagrants and alien species excluded).

The ichthyofauna of the MPA hotspot includes narrow-range endemics such as the Amatola barb, *Barbus amatolicus* and the Border barb, *B. trevelyani* of the Amatola Mountains, the Eastern Cape rocky, *Sandelia bainsii* of Albany, the redtail barb, *Barbus gurneyi* and Tugela labeo, *Labeo rubromaculatus* of KwaZulu-Natal and the pennant-tailed suckermouth, *Chiloglanis anoterus* of Maputaland, together with the secondary freshwater endemics Sibayi goby, *Silhouettea sibayi* in Maputaland and the golden sleeper, *Hypseleotris dayi* along the coast of Maputaland and KwaZulu-Natal. The barbs in genus *Barbus* show the highest diversity and endemicity amongst fishes in the MPA hotspot with 18 indigenous species, 3 of which (mentioned above) are endemic and 2 are near endemic to the hotspot. The amphibian fauna of the MPA hotspot includes two endemic genera: the monotypic genus *Natalobatrachus* represented by the kloof frog, *N. bonebergi* (restricted to the KwaZulu-Natal coastal belt and Pondoland), and the genus *Anhydrophryne*, represented by the Natal chirping frog, *A. hewitti* and the mistbelt chirping frog, *A. ngongoniensis*, narrow-range endemics in KwaZulu-Natal and the KwaZulu-Natal Midlands, respectively, together with the Hogsback chirping frog, *A. rattrayi*, largely restricted to the Amatola Mountains. Amongst the reptiles, the monotypic endemic genus *Macrelaps* is represented by the Natal black snake, *M. microlepidotus*, restricted to Maputaland, KwaZulu-Natal and Podoland. Prominent reptile genera showing a great deal of diversification and narrow endemism within the hotspot are flat geckos in the genus *Afroedura* (15 species: 6 endemic and 7 near endemic), dwarf burrowing skinks in the genus *Scelotes* (11 species: 7 endemic and 3 near endemic) and dwarf chameleons in the genus *Bradypodion* (9 species: 8 endemic and 1 near endemic). Even though the avifauna shows the highest species richness in the MPA hotpsot, there are no endemic birds in the hotspot. However, 14 bird species are listed in Appendix 1 as near endemic to the MPA hotspot, with ranges extending towards the south-eastern escarpment and/or Knysna. The hotspot also forms a part of BirdLife International's 'South-east African Coast' endemic bird area[52] with species extending north from the MPA hotspot along the coastal belt. The only three species of mammals endemic to the MPA hotspot are two golden moles (the giant golden mole, *Chrysospalax trevelyani* and Marley's golden mole, *Amblysomus marleyi*, narrowly endemic to the Transkei coastal belt and Maputaland, respectively), and one shrew (Sclater's forest shrew, *Myosorex sclateri* in KwaZulu-Natal). However, the numerous non-endemic species make the hotspot an important area for small mammals, especially for golden moles (with seven species representing five genera, two of which are endemic and one is near endemic in the MPA hotspot).

TABLE 1: Vertebrate species richness and endemism in the Maputaland-Pondoland-Albany (MPA) biodiversity hotspot, as currently defined, and according to data from two additional sources, Mittermeier et al.[2] and Conservation International[9].

Class	Current assessment					Mittermeier et al.[2] (2004)		Conservation International[9] (2005)	
	Number of families	Number of genera	Number of species	Endemic species	Near endemic species	Number of species	Endemic species	Number of species	Endemic species
Mammalia	37	129	198 (1[mg])	3 (1.5%)	3 (1.5%)	193	5 (2.6%)	194	4 (2.1%)
Aves	86	300	617 (72[mg])	0 (0%)	14 (2.3%)	541	0 (0.0%)	541	0 (0.0%)
Reptilia	24	83	230	33 (14.3%)	25 (10.9%)	205	36 (17.6%)	209	30 (14.4%)
Amphibia	12	26	75	16 (21.3%)	8 (10.7%)	80	12 (15.0%)	72	11 (15.3%)
Pisces	25	48	97 (24[sf])	10 (10.3%)	10 (10.3%)	73	20 (27.4%)	no data	no data
Total	**184**	**586**	**1217**	**62 (5.1%)**	**60 (4.9%)**	**1092**	**73 (6.7)**	**1016**	**45 (4.4%)**

Note: Please see the full reference list of the article, Perera SJ, Ratnayake-Perera D, Procheş Ş. Vertebrate distributions indicate a greater Maputaland-Pondoland-Albany region of endemism. S Afr J Sci. 2011;107(7/8), Art. #462, 15 pages. doi:10.4102/sajs.v107i7/8.462, for more information.
[mg], non-breeding migrants; [sf], secondary freshwater fish species – coastal/estuarine species that also occur in fresh water.
Percentage endemism is given in parentheses, and calculated out of all regularly occurring indigenous vertebrate species within the MPA hotspot (breeding residents, migrants and secondary freshwater fish), excluding vagrant birds and introduced or alien species.

Vertebrate taxa endemic to south-eastern Africa

A total of 495 vertebrate taxa (259 species and 236 infraspecific taxa) were found to have restricted ranges endemic to south-eastern Africa (see last panel in Figure 1), making the area an important region of vertebrate endemism, especially for reptiles (211 endemic taxa). Birds, as expected, showed higher endemism in infraspecific taxa (88) than in species (44), as their mobility retards isolation-driven speciation, whilst greater numbers of endemic species compared to infraspecific taxa were recorded for the herpetofauna (with endemic species: endemic infraspecific taxa ratios of 131:80 in reptiles and 33:09 in amphibians), although it can be argued that many more taxa await description.

Endemic vertebrate distributions

A total of 23 EVDs were identified within the study area based on the distribution ranges of 495 endemic taxa. Figure 1 presents maps for all EVDs, together with the numbers of endemic species and infraspecific taxa they harbour for each vertebrate class. Different EVDs were found to possess exceptionally high endemism for different vertebrate classes. For example, from north to south, the Eastern Escarpment EVD had the highest number of endemic reptile taxa (28 taxa: 19 species and 9 infraspecific taxa) and endemic mammal taxa (8 taxa: 2 species and 6 infraspecific taxa); the Maputaland EVD had the highest number of endemic freshwater fish taxa (12 endemic taxa: 2 species and 10 infraspecific taxa); the KwaZulu-Natal EVD had the highest number of endemic amphibian taxa (9 endemic species); and the Escarpment Extension of the South-eastern Coast EVD had the highest number of endemic bird taxa (18 taxa: 5 species and 13 infraspecific taxa). In general, the Eastern Escarpment, KwaZulu-Natal, Drakensberg, and Maputaland are the most outstanding amongst the narrow-range EVDs in south-eastern Africa (with 26, 20, 15 and 12 endemic species, respectively), and hence can be regarded as priority areas for vertebrate conservation.

The greater Maputaland-Pondoland-Albany region of vertebrate endemism

There are seven narrow-range EVDs in south-eastern Africa: Maputaland, KwaZulu-Natal, Transkei Coastal Belt and Albany Coastal Belt along the south-eastern coast, and the Eastern Escarpment, Drakensberg and Amatola-Winterberg-Sneeuberg along the south-eastern Great Escarpment (Figure 2a). These narrow-range EVDs together with two EVDs showing endemic range extensions from the coastal belt towards the escarpment (the Escarpment Extension EVD and the Escarpment and Knysna Extension EVD of the south-eastern coast; Figure 2b), and two transitional extensions (the Inhambane and Mopane Extension in the north-east and the Knysna Extension in the south-west; Figure 2b), were used to demarcate a Greater Maputaland-Pondoland-Albany (GMPA) region of vertebrate endemism (Figure 2b and 2c). Some species, such as the bronze caco, *Cacosternum nanum*; chorister robin-chat, *Cossypha dichroa*; Knysna turaco, *Tauraco corythaix* and Hottentot golden mole, *Amblysomus hottentotus* have distributions almost identical to the extent of the GMPA region. The Maputaland, KwaZulu-Natal, Transkei Coastal Belt and Albany Coastal Belt EVDs form the coastal section of the GMPA region, largely matching the borders of the MPA hotspot, whilst the Eastern Escarpment, Drakensberg and Amatola-Winterberg-Sneeuberg EVDs are situated inland, forming the Great Escarpment section of the GMPA region.

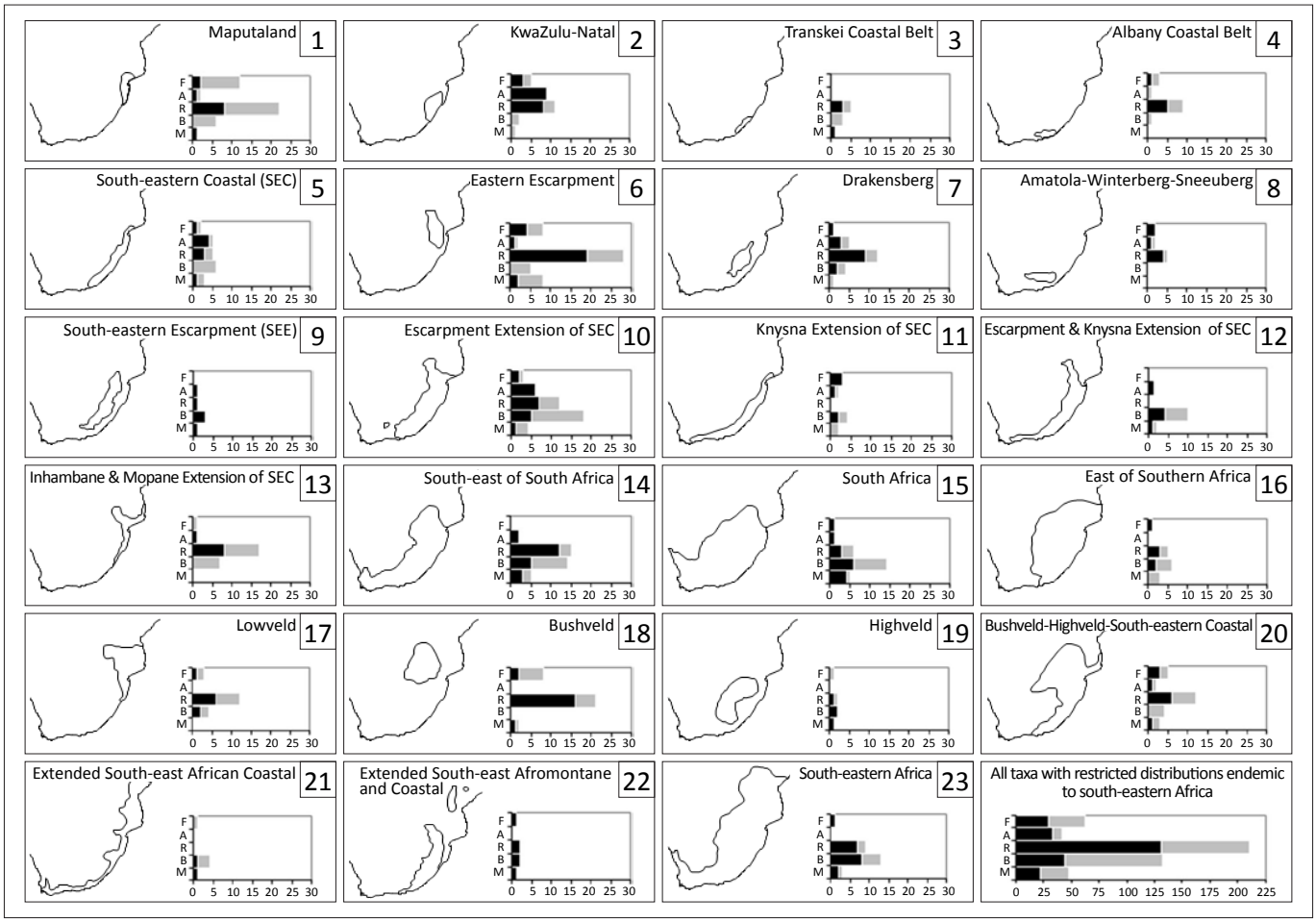
The total vertebrate endemism of the GMPA region is thus as high as 146 species (19 freshwater fishes, 29 amphibians, 75 reptiles, 15 birds and 8 mammals – see Appendix 1), 135% higher than for the MPA hotspot (62 species), within an area only 73% larger than the hotspot (~274 316 km^2).[7] The area added by the Inhambane and Mopane and the Knysna transitional extensions overlaps with the Lowveld and Bushveld bioregions, and the Cape Floristic Region, respectively. If the overlaps were reduced to include only forest patches in these areas (where most of the elements characteristic of the GMPA region are found), then the actual increase in area would be even smaller. Even if the GMPA region excluded these transitional extensions, it would still include 125 endemic species (a 103% increase in endemism from the MPA hotspot), with an increase in area of only 50%.

It is particularly remarkable that the GMPA region harbours 15 endemic bird species in contrast to the MPA hotspot, which has no endemic bird species. Three reptile genera extralimital to the MPA hotspot (genera of the Woodbush legless skink, *Acontophiops*; the Swazi rock snake, *Inyoka* and the cream-spotted mountain snake, *Montaspis*), together with the amphibian genus of the Natal cascade frog *Hadromophryne* and the bird genus of the bush blackcap *Lioptilus*, all monotypic and extending towards the escarpment from the MPA hotspot, are endemic within the GMPA region. This results in a total of eight genera (three amphibian genera – *Anhydrophryne, Hadromophryne* and *Natalobatrachus*, four reptile genera – *Acontophiops*, *Inyoka, Macrelaps* and *Montaspis* and the bird genus *Lioptilus*) endemic to the GMPA region, in contrast to the only three vertebrate genera (*Anhydrophryne, Natalobatrachus* and *Macrelaps*) endemic to the MPA hotspot. Furthermore, two golden mole genera, namely *Chrysospalax* and *Neamblysomus*, are near endemic to the GMPA region (each genus having two species, one of each endemic to the GMPA region and the others extending to the Northern Mesic Highveld and Central Bushveld bioregions, respectively[29]). Appendix 1 lists all the vertebrate species endemic to the GMPA region, their status within the MPA hotspot and the EVDs they are characteristic to.

Zoogeographical units and areas of vertebrate endemism

Using the core regions of EVDs, their overlapping margins and the patterns of narrower endemism within them, we demarcated 24 non-overlapping zoogeographical units within the GMPA region (Figure 2c), including 13 AOVEs (Table 2).

Overall, 37 zoogeographical units (Figure 3) can be recognised for south-eastern Africa (south of 22°S and east



Bar graphs represent the numbers of endemic species (black bars) and disjunct infraspecific taxa (grey bars), fitting each endemic vertebrate distribution (F, freshwater fish; A, amphibians; R, reptiles; B, birds; M, mammals).

FIGURE 1: Endemic vertebrate distributions (EVDs) in south-eastern Africa: Narrow-range EVDs along the south-eastern coast (1–4), South-eastern Coastal composite EVD (5), narrow-range EVDs along the south-eastern escarpment (6–8), South-eastern Escarpment composite EVD (9), EVDs extending from the south-eastern coast (10–13) and other broader EVDs (14–23).

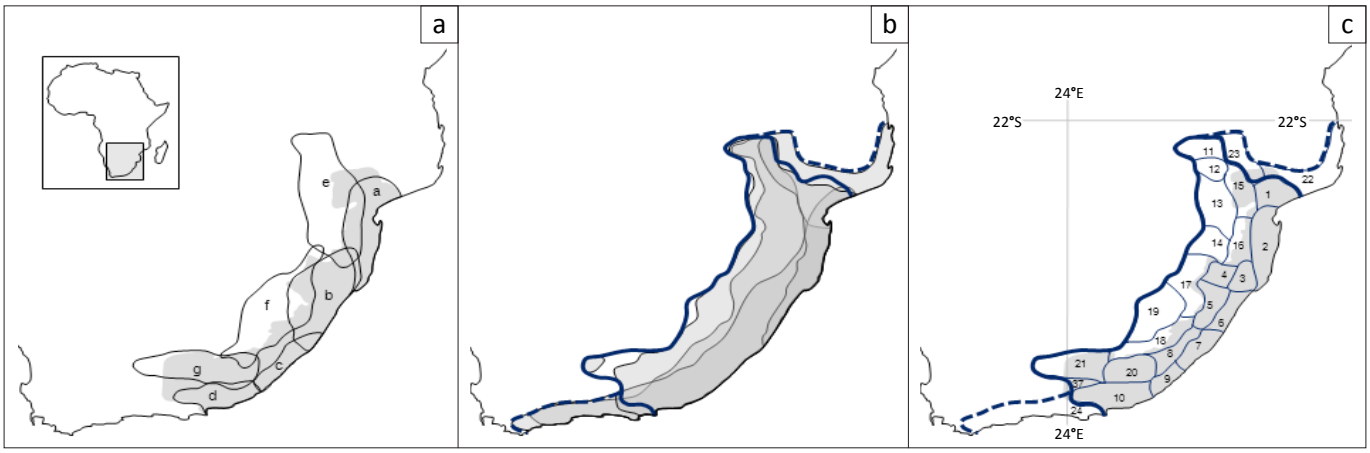


FIGURE 2: Stages in the drafting of the proposed zoogeographical regionalisation of the Greater Maputaland-Pondoland-Albany (GMPA) region of vertebrate endemism: (a) The narrow-range endemic vertebrate distributions (EVDs) used in the delimitation of the GMPA region (see panes 1–4 and 6–8 in Figure 1). The MPA hotspot as currently defined is shaded. (b) The broad-range EVDs used in the delimitation of the GMPA region (see panes 10–13 in Figure 1). The thick line depicts the GMPA region, whilst the broken lines show its transitional extensions. (c) The GMPA region of vertebrate endemism showing its 24 zoogeographical units, delimited from the core regions of EVDs, their overlapping margins and patterns of narrower endemism within them. Numbers 1–24 and 37 depict the same zoogeographical units as given in Figure 3. Thick lines as in pane (b); shading as in pane (a).

of 24˚E) based on the EVDs illustrated in Figure 1. Of these, 14 represent AOVEs (13 are within the GMPA region and listed in Table 2 and 1 AOVE represents the Waterberg), whilst 7 are transitional units because taxa occupying them show considerable links with units on either side of them: the Northern Mopane, Southern Mopane, Inhambane, Northern Middleveld, Southern Middleveld, KwaZulu-Natal Midlands and Knysna (the Northern Middleveld, Southern

Middleveld and KwaZulu-Natal Midlands transitional units are also AOVEs). The characteristic narrow endemics of each AOVE are listed in Table 3.

Within the GMPA region, six units are relatively endemic poor: the Southern Mpumalanga Escarpment, Northern Maputaland, Northern KwaZulu-Natal, Drakensberg Plateau, Transkei Midlands and Southern Transkei Coastal Belt; amongst which the last two, taken together, provide evidence for the existence of a 'Transkei gap'.[53]

Discussion

Methods revisited

We used the distribution ranges of endemic vertebrate taxa to qualitatively identify a region of conservation priority as well as zoogeographical units for south-eastern Africa, given that the distribution databases for some taxa are far from complete and not particularly accurate. The available distribution data for different vertebrate classes in south-eastern Africa vary considerably in their completeness and resolution, as a result of varied intensities of collection and different scales of mapping. Some of the available atlas data sets do not completely cover our study region (most being limited to South Africa, Lesotho and Swaziland), and other references from which these data can be supplemented give distribution maps at different resolutions. Therefore, we used a qualitative approach to delimit EVDs congruent amongst vertebrate classes. From these, a set of zoogeographical units were developed in order to incorporate the available data into a subsequent rigorous numerical analysis, reducing both data incompleteness (as compared to QDSs), and the arbitrary nature of boundaries (compared to half- or full-degree squares if QDS data were to be pooled). However, data are far scarcer in most of the world's biodiversity hotspots (e.g. the Guinean Forests of West Africa,[54] the Himalayas,[55] Indo-Burma,[56] Western Ghats and Sri Lanka[57]). Hence we propose EVDs as a tool for understanding biogeographical patterns, refining the boundaries of biodiversity hotspots and identifying local conservation priorities within them, where distribution data are inappropriate for comprehensive numerical analyses.

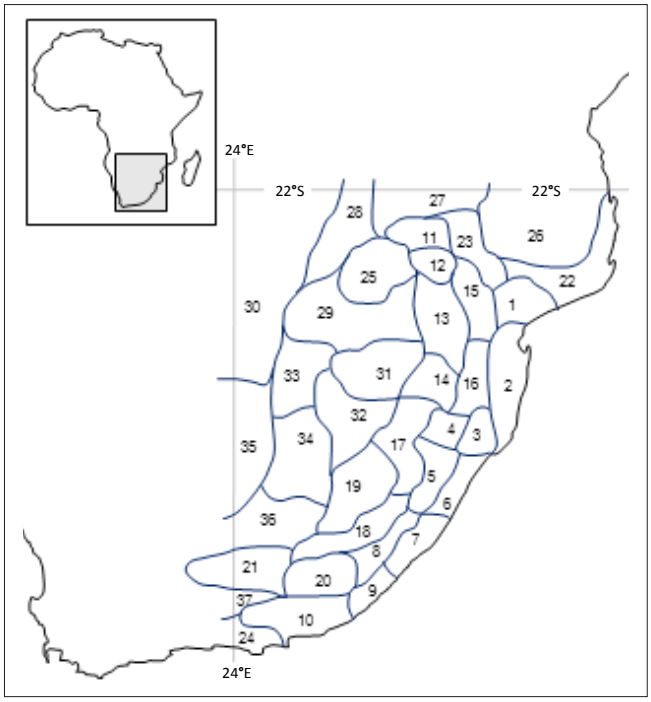
Vertebrate endemism in the Maputaland-Pondoland-Albany biodiversity hotspot as currently defined

Although the MPA hotspot is identified as a biodiversity hotspot primarily based on its floristic endemism, it is evident that vertebrates also show an increased endemism in and towards the hotspot, albeit with comparatively lower degrees of endemism (5.1%) and near-endemism (4.9%) than is the case for plants, which have a degree of endemism of 23.5%.[2] Vertebrate endemism in the MPA hotspot is comparable with that of the Succulent Karoo (4.2%) but lower than that of the Cape Floristic Region (10.3%), the other southern African biodiversity hotspots. It is certainly low by global standards, with the MPA hotspot ranking 31st out of the 34 biodiversity hotspots currently recognised.[2] The figure for vertebrate endemism in the MPA hotspot is largely stable in comparison with prior assessments (Table 1), although many details have changed since, because of the discovery of new species (e.g. cacos, *Cacosternum* spp., flat geckos, *Afroedura* spp. and dwarf chameleons, *Bradypodion* spp.) and taxonomic revisions. The number of MPA-endemic fish species in Mittermeier et al.[2] seems to be erroneously higher than the actual values. This, together with the increase in species richness as a result of the availability of better distribution data, especially in birds,

TABLE 2: The greater Maputaland-Pondoland-Albany (GMPA) region of vertebrate endemism (146 endemic species), its two major geographical sections and areas of vertebrate endemism (AOVEs) within it.

Section of the GMPA region	Areas of vertebrate endemism
South-eastern Coastal section (51 endemic species)	Southern Maputaland (9+21)
	Ngoye (3+2)
	KwaZulu-Natal Midlands (6+0)
	KwaZulu-Natal Coastal Belt (3+4)
	Pondoland (2+3)
	Albany Coastal Belt (6+8)
South-eastern Escarpment section (54 endemic species)	Soutpansberg (2+5)
	Wolkberg (4+3)
	Northern Mpumalanga Escarpment (2+2)
	Northern Middleveld (7+3)
	Southern Middleveld (4+2)
	Drakensberg-KZN Escarpment (6+2)
	Amatola-Winterberg (5+2)

Number of endemic species + endemic disjunct infraspecific taxa for each area of vertebrate endemism is given in parentheses.



1, Northern Maputaland; 2, Southern Maputaland; 3, Ngoye; 4, Northern KwaZulu-Natal; 5, *KwaZulu-Natal Midlands*; 6, KwaZulu-Natal Coastal Belt; 7, Pondoland; 8, Transkei Midlands; 9, Southern Transkei Coastal Belt; 10, Albany Coastal Belt; 11, Soutpansberg; 12, Wolkberg; 13, Northern Mpumalanga Escarpment; 14, Southern Mpumalanga Escarpment; 15, *Northern Middleveld*; 16, *Southern Middleveld*; 17, Drakensberg-KwaZulu-Natal Escarpment; 18, Drakensberg-Eastern-Cape Escarpment; 19, Drakensberg Plateau; 20, Amatola-Winterberg; 21, Sneeuberg; 22, *Inhambane*; 23, *Southern Mopane*; 24, *Knysna*; 25, Waterberg; 26, Mozambique Lowveld; 27, *Northern Mopane*; 28, *Northern Bushveld*; 29, Central Bushveld; 30, Kalahari Bushveld; 31, Northern Mesic Highveld; 32, Southern Mesic Highveld; 33, Northern Dry Highveld; 34, Southern Dry Highveld; 35, Upper Karoo; 36, *Highveld-Upper Karoo*; 37, Succulent Karoo.
Note that italicised names depict transitional units.

FIGURE 3: Proposed zoogeographical units for south-eastern Africa delimited based on endemic vertebrate distributions.

TABLE 3: Characteristic narrow-range endemics in south-east African areas of vertebrate endemism.

Area of vertebrate endemism	Characteristic narrow endemic species
Albany Coastal Belt	*Sandelia bainsii, Bitis albanica, Cordylus tasmani, Goggia essexi, Nucras taeniolata, Scelotes anguineus*
Amatola-Winterberg	*Afroedura amatolica, Afroedura tembulica, Barbus amatolicus, Barbus trevelyani, Vandijkophrynus amatolicus*
Drakensberg-KZN Escarpment	*Afroedura nivaria, Bradypodion dracomontanum, Bradypodion* sp. nov. 'emerald', *Montaspis gilvomaculata, Pseudocordylus langi, Pseudocordylus spinosus*
KwaZulu-Natal Coastal Belt	*Hyperolius pickersgilli, Scelotes guentheri, Scelotes inornatus*
KwaZulu-Natal Midlands	*Anhydrophryne ngongoniensis, Bradypodion thamnobates, Cacosternum poyntoni, Cacosternum* sp. nov. 'A', *Leptopelis xenodactylus, Scelotes bourquini*
Ngoye	*Bradypodion caeruleogula, Bradypodion nemorale, Bradypodion ngomeense*
Northern Middleveld	*Afroedura* sp. nov. 'mariepi', *Afroedura* sp. nov. 'rupestris', *Afroedura* sp. nov. 'rondavelica', *Afroedura* sp. nov. 'granitica', *Barbus brevipinnis, Barbus treurensis, Chiloglanis bifurcus*
Northern Mpumalanga Escarpment	*Afroedura* sp. nov. 'leoleonsis', *Amblysomus robustus*
Pondoland	*Acontias poecilus, Bradypodion caffer*
Southern Maputaland	*Amblysomus marleyi, Bradypodion setaroi, Leptotyphlops telloi, Lycophidion pygmaeum, Platysaurus lebomboensis, Scelotes arenicolus, Scelotes fitzsimonsi, Scelotes vestigifer, Silhouettea sibayi*
Southern Middleveld	*Afroedura major, Afroedura* sp. nov. 'lebomboensis', *Afroedura* sp. nov. 'pongolae', *Varicorhinus nelspruitensis*
Soutpansberg	*Australolacerta rupicola, Platysaurus relictus*
Waterberg	*Afroedura* sp. nov. 'waterbergensis', *Cordylus breyeri, Lygodactylus waterbergensis, Platysaurus guttatus, Platysaurus minor*
Wolkberg	*Acontophiops lineatus, Lygodactylus methueni, Neamblysomus gunningi, Tetradactylus eastwoodae*

has contributed to the percentage endemism in the present assessment being lower than in Mittermeier et al.[2], despite the discovery of new endemic species. One other factor that accounts for differences between the numbers of species listed in previous assessments and the present one is the inclusion and exclusion of marginal species (see numbers for endemic species in the Critical Ecosystem Partnership Fund[10]). Here we took a conservative approach when dealing with marginal occurrences of species, taking their habitat preferences into consideration.

South-east African vertebrate endemism and its congruence with vegetation types

As one would expect, the EVDs described here showed a considerable degree of congruence with vegetation patterns (biomes and bioregions).[29] Most of the south-east African endemic vertebrates are associated with either forests or grasslands, and a few of them with thicket (in Albany and azonal fire-free habitat patches elsewhere) and with savanna (especially in northern South Africa). But, in general, most narrow endemic species occupy azonal microhabitats (e.g. rock outcrops and marshy areas) within those biomes and hence are not quite characteristic of the biomes as such. Some bioregions, such as the Dry Highveld Grasslands and Eastern Kalahari Bushveld, are poor in south-east African endemics.

Several narrow endemics of forest affinities fall within the south-eastern coastal belt, represented in patches of sand, scarp and coastal forest.[29] In addition, mistbelt forests[29] found along the sub-escarpment belt together with Afrotemperate[29] (Afromontane) forest patches along the Drakensberg-KwaZulu-Natal Escarpment, are also rich in endemic vertebrates. Forest patches that stand out in terms of vertebrate endemism (from north to south, with their respective endemics) are: the remnant Afromontane forests of the Wolkberg (Methuen's dwarf gecko, *Lygodactylus methueni* and Gunning's golden mole, *Neamblysomus gunningi*), the coastal (dune) forests of Southern Maputaland (e.g. Setaro's dwarf chameleon, *Bradypodion setaroi*; Zululand dwarf burrowing skink, *Scelotes arenicolus* and FitzSimons' dwarf burrowing skink, *S. fitzsimonsi*), the scarp and mistbelt forests of southern Zululand (our Ngoye 'area of endemism'; uMlalazi dwarf chameleon, *Bradypodion caeruleogula*; Qudeni dwarf chameleon, *B. nemorale* and Ngome dwarf chameleon, *B. ngomeense*), the mistbelt forest patches of the KwaZulu-Natal Midlands (Natal Midlands dwarf chameleon, *Bradypodion thamnobates*), the Afromontane forests along the Drakensberg-KwaZulu-Natal Escarpment (Drakensberg dwarf chameleon, *Bradypodion dracomontanum* and an undescribed dwarf chameleon species, *B.* sp. nov. 'emerald'), and the scarp forests of KwaZulu-Natal Coastal Belt and Pondoland (kloof frog, *Natalobatrachus bonebergi*), coastal forests of Pondoland (variable legless skink, *Acontias poecilus* and Pondo dwarf chameleon, *Bradypodion caffer)* and Southern Transkei Coastal Belt (giant golden mole, *Chrysospalax trevelyani*). In addition to the narrow endemics, a few avian forest endemics are found in most of the GMPA region (e.g. forest buzzard, *Buteo trizonatus*; chorister robin-chat, *Cossypha dichroa* and Knysna turaco, *Tauraco corythaix*).

Similarly, a few grassland endemics are fairly widespread in the GMPA region (e.g. Sloggett's vlei rat, *Otomys sloggetti* and the Natal red rock rabbit, *Pronolagus crassicaudatus*), whilst some sections of the grassland biome support narrow endemic vertebrates, namely, from north to south, the montane grasslands of the Wolkberg (Woodbush legless skink, *Acontophiops lineatus*) and Mpumalanga Escarpment (robust golden mole, *Amblysomus robustus*), the coastal grasslands of Southern Maputaland (pygmy wolf snake, *Lycophidion pygmaeum*), the mistbelt grasslands of the KwaZulu-Natal Midlands (mistbelt chirping frog, *Anhydrophryne ngongoniensis*; long-toed tree frog, *Leptopelis xenodactylus* and Bourquin's dwarf burrowing skink *Scelotes bourquini*), KwaZulu-Natal Midlands and Coastal Belt grasslands (striped caco, *Cacosternum striatum*), marshy areas within KwaZulu-Natal Coastal Belt grasslands (Pickersgill's reed frog, *Hyperolius pickersgilli*), montane grasslands along the Drakensberg-KwaZulu-Natal and Drakensberg-Eastern-Cape Escarpments (Drakensberg flat gecko, *Afroedura nivaria*; Lang's crag lizard, *Pseudocordylus langi*; Cottrell's mountain

lizard, *Tropidosaura cottrelli* and Essex's mountain lizard, *T. essexi*), alpine grasslands on the Drakensberg Plateau and Escarpments (Drakensberg river frog, *Amietia dracomontana*; Maluti river frog, *A. umbraculata*; Hall's flat gecko, *Afroedura halli*; mountain pipit, *Anthus hoeschi* and Drakensberg Siskin, *Crithagra symonsi*) and the montane grasslands of the Amatolas (Amatola flat gecko, *Afroedura amatolica*; Tembo flat gecko, *A. tembulica* and Amatola toad, *Vandijkophrynus amatolicus*), as well as the Sneeuberg (plain mountain adder, *Bitis inornata*).

Few narrow endemics inhabit thicket in the Albany Coastal Belt (Albany adder, *Bitis albanica*; Tasman's girdled lizard, *Cordylus tasmani* and the striped scrub lizard, *Nucras taeniolata*), and fire-free habitat patches elsewhere (e.g. Kentani dwarf chameleon, *Bradypodion kentanicum,* in the Transkei Coastal Belt). Similarly, few narrow-endemic vertebrates exist within the savanna biome: in the Waterberg – the Waterberg girdled lizard, *Cordylus breyeri*; dwarf flat lizard, *Platysaurus guttatus* and Waterberg flat lizard, *P. minor*; the Soutpansberg – the Soutpansberg rock lizard, *Australolacerta rupicola* and Soutpansberg flat lizard, *Platysaurus relictus*; and the Northern Mpumalanga Escarpment – the Sekhukhune flat lizard, *Platysaurus orientalis*), whilst relatively widespread savanna endemics are found in the Bushveld EVD (e.g. Van Dam's girdled lizard, *Cordylus vandami*; black-spotted dwarf gecko, *Lygodactylus nigropunctatus* and Juliana's golden mole, *Neamblysomus julianae*).

The Northern Middleveld, Southern Maputaland, KwaZulu-Natal Midlands, Drakensberg-KwaZulu-Natal Escarpment, Albany Coastal Belt and the Amatola-Winterberg stand out as the AOVEs with the highest numbers of characteristic narrow endemics within the GMPA region (that is, more than five; see Table 2). Interestingly, the narrow endemics within these richest AOVEs show major habitat affinities to forests, grasslands and thicket vegetation, emphasising the importance of these habitats for vertebrate endemism in the region.

The structural features of the flora determine the faunal assemblages in a region,[5] resulting in the narrow AOVEs coinciding well with vegetation units such as Ngoye, Pondoland and Albany Coastal Belt, even though broader EVDs tend to cut across different vegetation types. It is also evident that the patterns derived from vertebrates are largely congruent with van Wyk and Smith's[5] centres of floristic endemism, the most notable difference being in the delimitation of the Albany region, which is a single centre of plant endemism but encompasses two distinct EVDs. Whilst the prominent EVD of KwaZulu-Natal has not hitherto been formally recognised as a centre of plant endemism,[5] there are numerous narrow endemic plant species in the area[58] (e.g. dune aloe, *Aloe thraskii*; woolly calpurnia, *Calpurnia woodii*; sticky star-apple, *Diospyros glandulifera*; parrot tree erica, *Erica psittacina*; Tugela spikethorn, *Gymnosporia macrocarpa*; Wood's spikethorn, *G. woodii*; Rudatis' dwarf currant, *Searsia rudatisii* and Tugela bush-milkwood, *Vitellariopsis dispar*), albeit some have only recently been described.

Congruence of endemic vertebrate distributions and the greater Maputaland-Pondoland-Albany region with published zoogeographical regions

The GMPA region, as well as the narrow-range EVDs presented here, shows congruent patterns with published zoogeographical regionalisation schemes developed with numerical analyses for single vertebrate classes (Table 4). The faunal zones identified by Crowe[26] for southern African vertebrates also captured similar patterns, with frogs, lizards, snakes and birds having increased species richness towards the GMPA region, whilst the herpetofauna also showed an increased endemism towards the GMPA region.

TABLE 4: Congruence of the Greater Maputaland-Pondoland-Albany (GMPA) region and some endemic vertebrate distributions (EVDs) illustrated here with published zoographical regionalisations for amphibians and birds.

Region/ EVD (present study)	Published zoogeographical regionalisations			
	Amphibians		Birds	
	Poynton[18]	Alexander et al.[25]	Crowe and Crowe[19]	De Klerk et al.[24]
GMPA region (excluding transitional extensions)	Congruent with SEL + ST (excl. Cape ext.)	Congruent with EECD (*sensu lato*)	Congruent with SED (*sensu lato*)	Congruent with TPP (*sensu lato*)
South-eastern Coastal EVD	Congruent with SEL	Within EECD	Within SED	Within TPP
South-eastern Escarpment EVD	Congruent with ST (excl. Cape ext.)	Marginally within EECD	Marginally within SED	Marginally within TPP
Maputaland EVD	At the southern tip of EAL, marginally in SEL	Within MA	Within SED	Within TPP
Natal EVD	Within SEL	Southern tip of MA and mid-SoGA	Within SED	Within TPP
Pondoland EVD	Within SEL	Southern tip of SoGA	Within SED	Within TPP
Albany Coastal Belt EVD	Within SEL	Within SCECUA	Within SED	Within TPP
Eastern Escarpment EVD	Within ST	Northern SoGA	Within SED	Within TPP
Drakensberg EVD	Within ST	Marginally between SoGA, SCECUA and south-east SwGA	Within SED	Marginally between TPP and HD
Amatola-Winterberg-Sneeuberg EVD	Within ST	Marginally between SCECUA and south-east SRKD	Marginally between SED and FD	Marginally between TPP and FD

Note: Please see the full reference list of the article, Perera SJ, Ratnayake-Perera D, Procheş Ş. Vertebrate distributions indicate a greater Maputaland-Pondoland-Albany region of endemism. S Afr J Sci. 2011;107(7/8), Art. #462, 15 pages. doi:10.4102/sajs.v107i7/8.462, for more information.
SEL, South-east Lowland Region; ST, South Temperate Region; EAL, East African Lowland Region; EECD, Eastern Escarpment/Coastal District of the Eastern Subregion; MA, Maputaland Assemblage of EECD; SoGA, Sour Grasslands Assemblage of EECD; SCECUA, South Coast/Eastern Cape Uplands Assemblage of EECD; SwGA, Sweet Grasslands Assemblage of Central District in Eastern Subregion; SRKD, Summer Rainfall Karoo District of Western Subregion; SED, South-east District; FD, Fynbos District (both SED and FD are within the Southern Province of Southern Savanna Subregion); TPP, Tongaland-Pondoland Province of Southern Savanna Subregion; HD, Highveld District of South-western Subregion; FD, Fynbos District of South-western Subregion.

The greater Maputaland-Pondoland-Albany region of vertebrate endemism and its conservation significance

The importance of the zoogeographically delimited GMPA region as a more comprehensive area for conservation prioritisation needs to be understood by comparing it with the MPA hotspot as currently defined. The coastal section of the GMPA region is largely congruent – if narrower – with the MPA hotspot. Inland, even though the hotspot encompasses most of the Amatola-Winterberg-Sneeuberg EVD and the southern parts of the Eastern Escarpment EVD, these extend well beyond the current boundary of the hotspot. Furthermore, some taxa occupying these EVDs continue their ranges along the Drakensberg Escarpment, which lies almost completely outside the hotspot. This incongruence explains the inconsistency between the current boundary of the MPA hotspot and the patterns of vertebrate endemism (Figure 2a). Only 82.3% of the MPA hotspot's endemism is captured within the coastal section of the GMPA region (Table 5), the remainder of the endemic species have ranges that extend towards the south-eastern Great Escarpment (mostly towards the Eastern Escarpment and a few towards the Amatola-Winterberg-Sneeuberg and Drakensberg EVDs: see Appendix 1). Hence, we propose that a GMPA region that merges coastal and escarpment EVDs represents a more natural region of vertebrate endemism.

The GMPA region can be further validated by vertebrate species near endemic to the MPA hotspot. Amongst the near endemics of the MPA hotspot, 53.3% were found extending from the coastal section towards the south-eastern Great Escarpment and hence are endemic to the GMPA region. Moreover, when the GMPA region is considered to include the Inhambane and Mopane and the Knysna transitional extensions, it encompasses 86.7% of the MPA hotspot's near endemics (Table 5 and Appendix 1). The eight MPA near endemics that are not endemic to the GMPA region nevertheless have their core populations restricted to the GMPA region, with disjunct satellite populations (namely. Barratt's warbler, *Bradypterus barratti* and Gurney's sugarbird, *Promerops gurneyi* with satellite populations in the Chimanimani-Nyanga Mountains of eastern Zimbabwe; the Natal mountain catfish, *Amphilius natalensis* in the Chimanimani-Nyanga Mountains and southern Malawi; Fornasini's worm snake, *Afrotyphlops fornasinii*, the golden blind legless skink, *Typhlosaurus aurantiacus* and the speckled quill-snouted snake, *Xenocalamus transvaalensis* in the Lowveld region; Phongolo suckermouth, *Chiloglanis emarginatus* in the Bushveld region; and the laminate vlei rat, *Otomys laminatus* in the Western Cape).

The mismatches between EVDs and boundaries of the MPA hotspot, in the south-west and especially in the north-west (Figure 2a), also validate the recognition of the GMPA region as a more natural region of conservation significance. The north-western boundary of the hotspot is currently delimited along the 1800 m a.s.l. contour, making several species with restricted ranges along this boundary near endemic to the MPA hotspot (six species of reptiles: the montane dwarf burrowing skink, *Scelotes mirus*; giant Swazi flat gecko, *Afroedura major* and four undescribed flat gecko species, *A.* sp. nov. 'mariepi', *A.* sp. nov. 'rupestris', *A.* sp. nov. 'rondavelica' and *A.* sp. nov. 'granitica', together with four freshwater fish species: the shortfin barb, *Barbus brevipinnis*; Treur River barb, *B. treurensis*; Incomati suckermouth, *Chiloglanis bifurcus* and Incomati chiselmouth, *Varicorhinus nelspruitensis*). These species are indeed restricted to a Middleveld strip along the slopes of the Eastern Escarpment, which we identify as a transition zone between the Bushveld and Lowveld bioregions. This transition zone descends to an elevation of about 1000 m a.s.l. and extends south through western Swaziland to north-western KwaZulu-Natal (west of the Lebombo Mountains). Whilst the aforesaid species occurring in the northern parts of the transition zone are near endemic to the MPA hotspot, species occupying its southern parts, like the undescribed flat geckos, *Afroedura* sp. nov. 'lebomboensis' and *Afroedura* sp. nov. 'pongolae', are endemic to the hotspot, providing further evidence for the inconsistency of the hotspot boundary. In contrast, the GMPA region, with a more natural boundary, encompasses all of them as endemics. Along the south-western corner, the boundary of the MPA hotspot follows the Albany centre of plant endemism. In the demarcation of the Albany centre, van Wyk and Smith[5] incorporated a number of different floristic elements, creating a mosaic of bioregions within it. In contrast, the Albany Coastal Belt EVD is much narrower than the Albany centre of plant endemism. Here, the GMPA region encompasses two well-delimited EVDs, the Albany Coastal Belt and the Amatola-Winterberg-Sneeuberg, with coastal and escarpment affinities, respectively.

TABLE 5: Representation of the Maputaland-Pondoland-Albany (MPA) hotspot endemic and near endemic vertebrates within the Greater Maputaland-Pondoland-Albany (GMPA) region of vertebrate endemism.

Class	Species endemic to MPA	Species near endemic to MPA	Species endemic to coastal section of GMPA	MPA near endemics	
				Endemic to GMPA (without transitional extensions)	Endemic to GMPA (with transitional extensions)
Mammalia	3	3	3	1	2
Aves	0	14	0	6	12
Reptilia	33	25	27	15	22
Amphibia	16	8	14	5	8
Pisces	10	10	7	5	8
Total	**62**	**60**	**51 (82.3%[a])**	**32 (53.3%[b])**	**52 (86.7%[b])**

[a], Percentage of the Maputaland-Pondoland-Albany hotspot endemics, endemic within the coastal section of the Greater Maputaland-Pondoland-Albany region.
[b], Percentage of the Maputaland-Pondoland-Albany hotspot near endemics, endemic within the Greater Maputaland-Pondoland-Albany region.

The existence of the GMPA region is also supported by plants, as shown by the distribution patterns of some species in the thicket genera: *Encephalartos* (Zamiaceae), *Rhoicissus* (Vitaceae) and *Cussonia* (Araliaceae),[59] whilst van Wyk's[60] notation on outliers of some Maputaland endemic plants supports the Inhambane and Mopane extension. Redefining Africa's biodiversity hotspots, Küper at al.[61] also proposed a region similar to the GMPA region (except for the Inhambane and Mopane extension) as a hotspot of higher plant endemism. The conservation importance of the area covered under the GMPA region is also supported by Olson and Dinerstein[62], who prioritised Maputaland-Pondoland Dry Forests as an example for the Tropical, Subtropical, Dry and Monsoon Broadleaf Forest Ecoregion, and the South African Montane Grasslands and Shrublands as an example for the Tropical Montane Grassland and Savanna Ecoregion. Whilst both the above ecoregions are represented within the GMPA region, the MPA hotspot alone only encompasses the Maputaland-Pondoland Dry Forests.

Conclusions

This study emphasises south-eastern Africa as an important region for endemic vertebrates, especially with respect to herpetofauna. It also provides evidence for congruent endemic distributions amongst different vertebrate taxa, deriving patterns largely congruent with recognised centres of floristic endemism. The importance of the MPA hotspot is assessed for vertebrate endemism, providing less convincing evidence when compared to its flora. But the fact that vertebrate endemism in south-eastern Africa is concentrated towards the coastal belt and adjacent sections of the Great Escarpment provides an option to expand the boundaries of the MPA hotspot to include relevant Afromontane AOVEs. Supported by the zoogeographical links between the coastal and escarpment EVDs, the GMPA region of vertebrate endemism is proposed to serve as a better and more natural region of conservation significance. Simultaneously, the use of EVDs is proposed as a qualitative approach to identify conservation priorities, especially in situations where distributional data do not facilitate a numerical biogeographical analysis.

As suggested by White[45] and van Wyk and Smith[5], biogeographical patterns detected by means of intuitive perception should be followed by rigorous analysis to establish the extent of biogeographical regions and centres of endemism. Hence, the zoogeographical units presented in this paper are meant to be used in rigorous numerical analyses (e.g. Born et al.[63] – for the Greater Cape Floristic Region). Even though it is far from complete, the understanding of invertebrate diversity and distribution in southern Africa is better than in many parts of the world. Hence, the distributional data on invertebrates also need to be incorporated into such a rigorous analysis to visualise the broader picture of faunal endemism – invertebrates forming an incomparably higher share of the fauna than vertebrates. Finally, linking the AOVEs to the phylogenetic relatedness of the congruent, range-restricted taxa occupying them will provide clues to the origin and evolution of the faunal endemism in south-eastern Africa, revealing its historical biogeography. Simultaneously, the incorporation of these patterns of endemism in systematic conservation planning is envisaged, prioritising the AOVEs with high congruence across taxa.

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References

1. Myers N, Mittermeier RA, Mittermeier CG, Da Fonseca GAB, Kent J. Biodiversity hotspots for conservation priorities. Nature. 2000;403:853–858. doi:10.1038/35002501, PMid:10706275
2. Mittermeier RA, Robles-Gil P, Hoffmann M, et al., editors. Hotspots revisited: Earth's biologically richest and most endangered terrestrial ecoregions. Mexico City: CEMEX; 2004.
3. Wilson KA, McBride MF, Bode M, Possingham HP. Prioritising global conservation efforts. Nature. 2006;440:337–340. doi:10.1038/nature04366, PMid:16541073
4. Driver A, Maze K, Lombard AT, et al. South African national spatial biodiversity assessment 2004: Summary report. Pretoria: South African National Biodiversity Institute; 2004.
5. Van Wyk AE, Smith GF. Regions of floristic endemism in southern Africa. Pretoria: Umdaus Press; 2001.
6. Leader-Williams N, Dublin HT. Charismatic megafauna as 'flagship species'. In: Entwistle A, Dunstone N, editors. Priorities for the conservation of mammalian diversity: Has the panda had its day? Cambridge: Cambridge University Press, 2000; p. 53–81.
7. Steenkamp Y, van Wyk AE, Victor JE, et al. Maputaland-Pondoland-Albany. In: Mittermeier RA, Robles-Gil P, Hoffmann M, et al., editors. Hotspots revisited: Earth's biologically richest and most endangered terrestrial ecoregions. Mexico City: CEMEX, 2004; p. 218–229.
8. White F. The vegetation of Africa: A descriptive memoir to accompany the UNESCO/AETFAT/UNSO vegetation map of Africa (Natural Resources Research 20). Paris: UNESCO; 1983.
9. Conservation International. Biodiversity hotspots: Terrestrial vertebrate species database [homepage on the Internet]. c2005 [updated 2005 Feb 02; cited 2010 Aug 17]. Available from: http://www.biodiversityhotspots.org/xp/Hotspots/search/Pages/search.aspx
10. Critical Ecosystem Partnership Fund. Ecosystem profile: Maputaland-Pondoland-Albany biodiversity hotspot [document on the Internet]. c2010 [updated 2010 Feb 26; cited 2010 Apr 16]. Available from: http://www.cepf.net/Documents/DC_Finaldraft_MPAHprofile_Feb262010.pdf
11. Kier G, Kreft H, Lee TM, et al. A global assessment of endemism and species richness across island and mainland regions. Proc Natl Acad Sci USA. 2009;106:9322–9327. doi:10.1073/pnas.0810306106, PMid:19470638, PMCid:2685248
12. Raxworthy CJ, Nussbaum RA. Patterns of endemism for terrestrial vertebrates in eastern Madagascar. In: Lourenço WR, editor. Biogéographie de Madagascar. Paris: ORSTOM, 1996; p. 369–383.
13. Cowling RM, Pressey RL. Introduction to systematic conservation planning in the Cape Floristic Region. Biol Conserv. 2003;112:1–13. doi:10.1016/S0006-3207(02)00418-4
14. Linder P. Numerical analyses of African plant distribution patterns. In: Huxley CR, Lock JM, Cutler DF, editors. Chorology, taxonomy and ecology of the floras of Africa and Madagascar. Kew: Royal Botanic Gardens, 1998; p. 67–86.
15. Linder HP, Lovett J, Mutke JM, et al. A numerical re-evaluation of the sub-Saharan phytochoria of mainland Africa. Biol Skrift. 2005;55:229–252.
16. Ramdhani S, Barker NP, Baijnath H. Exploring the Afromontane centre of endemism: *Kniphofia* Moench (Asphodelaceae) as a floristic indicator. J Biogeogr. 2008;35:2258–2273. doi:10.1111/j.1365-2699.2008.01982.x
17. Poynton JC. The Amphibia of southern Africa: A faunal study. Ann Natal Mus. 1964;17:1–334.
18. Poynton JC. Distribution of amphibians in sub-saharan Africa, Madagascar, and Seychelles. In: Duellmann WE, editor. Patterns of distribution of amphibians, a global perspective. Baltimore: John Hopkins University Press, 1999; p. 483–539.

19. Crowe TM, Crowe AA. Patterns of distribution, diversity and endemism in Afrotropical birds. J Zool (Lond). 1982;198:417–442.
20. Guillet A, Crowe TM. Patterns of distribution, species richness, endemism and guild composition of water-birds in Africa. Afr J Ecol. 1985;23:89–120. doi:10.1111/j.1365-2028.1985.tb00719.x
21. Guillet A, Crowe TM. A preliminary investigation of patterns of distribution and species richness of southern African waterbirds. S Afr J Wildl Res. 1986;16:65–81.
22. Turpie JK, Crowe TM. Patterns of distribution, diversity and endemism of larger African mammals. S Afr J Zool. 1994;29:19–32.
23. Seymour CL, de Klerk HM, Channing A, Crowe TM. The biogeography of the Anura of sub-equatorial Africa and the prioritisation of areas for their conservation. Biodiversity Conserv. 2001;10:2045–2076. doi:10.1023/A:1013137409896
24. De Klerk HM, Crowe TM, Fjeldså J, Burgess ND. Biogeographical patterns of endemic terrestrial Afrotropical birds. Divers Distrib. 2002;8:147–162. doi:10.1046/j.1472-4642.2002.00142.x
25. Alexander GJ, Harrison JA, Fairbanks DH, Navarro RA. Biogeography of the frogs of South Africa, Lesotho and Swaziland. In: Minter LR, Burger M, Harrison JA, Braack HH, Bishop PJ, Kloepfer D, editors. Atlas and red data book of the frogs of South Africa, Lesotho and Swaziland. SI/MAB Series no. 9. Washington DC: Smithsonian Institution, 2004; p. 31–47.
26. Crowe TM. A quantitative analysis of patterns of distribution, species richness and endemism in southern African vertebrates. In: Peters G, Hutterer R, editors. Vertebrates in the tropics: Proceedings of the International Symposium on Vertebrate Biogeography and Systematics in the Tropics; 1989 June 5–8; Bonn, Germany. Bonn: Museum Alexander Koenig; 1990. p. 145–160.
27. Nordenstam B. Phytogeography of the genus Euryops (Compositae). A contribution to the phytogeography of southern Africa. Opera Botanica. 1969:23:7–77.
28. Clark VR, Barker NP, Mucina L. The Sneeuberg: A new centre of floristic endemism on the Great Escarpment, South Africa. S Afr J Bot. 2009;75:196–238. doi:10.1016/j.sajb.2008.10.010
29. Mucina L, Rutherford MC. The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. Pretoria: South African National Biodiversity Institute; 2006.
30. Larsen R, Holmern T, Prager SD, Maliti H, Røskaft E. Using the extended quarter degree grid cell system to unify mapping and sharing of biodiversity data. Afr J Ecol. 2009;47:382–392. doi:10.1111/j.1365-2028.2008.00997.x
31. Skelton PH. A complete guide to the freshwater fishes of southern Africa. Johannesburg: Southern Book Publishers; 1993.
32. Skelton PH. Changes to the scientific and common names of southern African freshwater fishes. Afr J Aquat Sci. 2002;27:171–174. doi:10.2989/16085914.2002.9626588
33. Froese R, Pauly D, editors. FishBase [homepage on the Internet]. c2009 [updated 2009 Aug; cited 2010 Feb 28]. Available from: http://www.fishbase.org
34. Minter LR, Burger M, Harrison JA, Braack HH, Bishop PJ, Kloepfer D, editors. Atlas and red data book of the frogs of South Africa, Lesotho and Swaziland. SI/MAB Series no. 9. Washington DC: Smithsonian Institution; 2004.
35. Du Preez L, Carruthers V. A complete guide to the frogs of southern Africa. Cape Town: Struik Nature; 2009.
36. Animal Demography Unit. The virtual museum: Southern African reptile conservation assessment [homepage on the Internet]. c2010 [updated 2010 Jan 29; cited 2010 Jan 31]. Available from: http://sarca.adu.org.za
37. Branch B. Field guide to snakes and other reptiles of southern Africa. Cape Town: Struik; 1998.
38. Harrison JA, Allan DG, Underhill LG, et al. editors. The atlas of southern African birds. Johannesburg: BirdLife South Africa; 1997.
39. Hockey PAR, Dean WRJ, Ryan PG, editors. Robert's birds of southern Africa. 7th ed. Cape Town: The Trustees of the John Voelcker Bird Book Fund; 2009.
40. Skinner DS, Chimimba CT. The mammals of the southern African subregion. 3rd ed. Cambridge: Cambridge University Press; 2005.
41. Kelly CMR, Branch WR, Broadley DG, Barker NP, Villet MH. Molecular systematics of the African snake family Lamprophiidae Fitzinger, 1843 (Serpentes: Elapoidea), with particular focus on the genera *Lamprophis* Fitzinger 1843 and *Mehelya* Csiki 1903. Mol Phylogenet Evol. 2011;58:415–426. doi:10.1016/j.ympev.2010.11.010, PMid:21095234
42. Alström P, Ericson PGP, Olsson U, Sundberg P. Phylogeny and classification of the avian superfamily Sylvioidea. Mol Phylogenet Evol. 2006;38:381–397. doi:10.1016/j.ympev.2005.05.015, PMid:16054402
43. Johansson US, Fjeldså J, Bowie RCK. Phylogenetic relationships within Passerida (Aves: Passeriformes): A review and a new molecular phylogeny based on three nuclear intron markers. Mol Phylogenet Evol. 2008;48:858–876. doi:10.1016/j.ympev.2008.05.029, PMid:18619860
44. Kelly CMR, Barker NP, Villet MH, Broadley DG. Phylogeny, biogeography and classification of the snake superfamily Elapoidea: A rapid radiation in the late Eocence. Cladistics. 2009;25:38–63. doi:10.1111/j.1096-0031.2008.00237.x
45. White F. The AETFAT chorological classification of Africa: History, methods and applications. Bull Jard Bot Nat Belg. 1993;62:225–281. doi:10.2307/3668279
46. Procheş Ş. The world's biogeographical regions: Cluster analyses based on bat distributions. J Biogeogr. 2005;32:607–614. doi:10.1111/j.1365-2699.2004.01186.x
47. Kreft H, Jetz W. A framework for delineating biogeographical regions based on species distributions. J Biogeogr. 2010;37:2029–2053. doi:10.1111/j.1365-2699.2010.02375.x
48. Wallace AR. The geographic distribution of animals. New York: Harper; 1876.
49. Botts EA, Erasmus BFN, Alexander GJ. Geographic sampling bias in the South African Frog Atlas Project: Implications for conservation planning. Biodivers Conserv. 2011:20:119–139. doi:10.1007/s10531-010-9950-6
50. Linder HP, Mann DM. The phylogeny and biogeography of *Thamnochortus* (Restionaceae). Bot J Linn Soc. 1998;128:319–357. doi:10.1111/j.1095-8339.1998.tb02125.x
51. Nelson G, Platnick N. Systematics and biogeography: Cladistics and vicariance. New York: Columbia University Press; 1981.
52. Stattersfield AJ, Crosby MJ, Long AJ, Wege DC. Endemic bird areas of the world: Priorities for conservation. Series no. 7. Cambridge: BirdLife International, BirdLife Conservation; 1998.
53. Vernon CJ. Biogeography, endemism and diversity of animals in the Karoo. In: Dean WRJ, Milton SJ, editors. The Karoo: Ecological patterns and processes. Cambridge: Cambridge University Press, 1999; p.57–78. doi:10.1017/CBO9780511541988.008
54. Critical Ecosystem Partnership Fund. Ecosystem profile: Upper Guinean forest ecosystem of the Guinean forests of west Africa biodiversity hotspot [document on the Internet]. c2000 [updated 2000 Dec 14; cited 2010 Aug 12]. Available from: http://www.cepf.net/Documents/final.guineanforests.upperguineanforest.ep.pdf
55. Critical Ecosystem Partnership Fund. Ecosystem profile: Eastern Himalayas region [document on the Internet]. c2005 [updated 2005 Feb; cited 2010 Aug 12]. Available from: http://www.cepf.net/Documents/final.ehimalayas.ep.pdf
56. Critical Ecosystem Partnership Fund. Ecosystem profile: Indo-Burma biodiversity hotspot – Indochina region [document on the Internet]. c2007 [updated 2007 May; cited 2010 Aug 12]. Aavailable from: http://www.cepf.net/Documents/final.indoburma_indochina.ep.pdf
57. Gunawardene NR, Daniels AED, Gunatilleke IAUN, et al. A brief overview of the Western Ghats-Sri Lanka biodiversity hotspot. Curr Sci. 2007;93:1567–1572.
58. Boon R. Pooley's trees of eastern South Africa: A complete guide. Durban: Flora and Fauna Publication Trust; 2010.
59. Cowling RM, Procheş Ş, Vlok JHJ. On the origin of southern African subtropical thicket vegetation. S Afr J Bot. 2005;71:1–23.
60. Van Wyk AE. Biodiversity of the Maputaland centre. In: Van der Maesen LJG, van der Burgt XM, van Medenbach de Rooy JM, editors. The biodiversity in African savannahs. Dordrecht: Kluwer Academic Publishers, 1996; p. 198–207.
61. Küper W, Sommer JH, Lovett JC, et al. Africa's hotspots of biodiversity redefined. Ann Missouri Bot Gard. 2004;91:525–535.
62. Olson DM, Dinerstein E. The Global 200: A representation approach to conserving the Earth's most biologically valuable ecoregions. Conserv Biol. 1998;12:502–515. doi:10.1046/j.1523-1739.1998.012003502.x
63. Born J, Linder HP, Desmet P. The greater Cape Floristic Region. J Biogeogr. 2006;34:147–162. doi:10.1111/j.1365-2699.2006.01595.x

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Appendix 1

APPENDIX 1: Endemic vertebrates of the Greater Maputaland-Pondoland-Albany (GMPA) region

Class	Family	Species	Status within MPA hotspot[a]	Representation in EVDs[b]
Pisces	Anabantidae	*Sandelia bainsii* (Eastern Cape Rocky)	End	ACB
Pisces	Cichlidae	*Chetia brevis* (Orange-fringed Largemouth)	N-End	Esc-Ext
Pisces	Cichlidae	*Serranochromis meridianus* (Lowveld Largemouth)	End	Esc-Ext
Pisces	Cyprinidae	*Barbus amatolicus* (Amatola Barb)	End	AWS
Pisces	Cyprinidae	*Barbus brevipinnis* (Shortfin Barb)	N-End	EE
Pisces	Cyprinidae	*Barbus gurneyi* (Redtail Barb)	End	KZN
Pisces	Cyprinidae	*Barbus treurensis* (Treur River Barb)	N-End	EE
Pisces	Cyprinidae	*Barbus trevelyani* (Border Barb)	End	AWS
Pisces	Cyprinidae	*Labeo rubromaculatus* (Tugela Labeo)	End	KZN
Pisces	Cyprinidae	*Labeobarbus natalensis* (Scaly)	End	KZN
Pisces	Cyprinidae	*Pseudobarbus afer* (Eastern Cape Redfin)	N-End	Kny-Ext
Pisces	Cyprinidae	*Pseudobarbus quathlambae* (Drakensberg Minnow)	M-Out	D
Pisces	Cyprinidae	*Varicorhinus nelspruitensis* (Incomati Chiselmouth)	N-End	EE
Pisces	Eleotridae	*Hypseleotris dayi* (Golden Sleeper)	End	SEC (M-KZN-CT)
Pisces	Gobiidae	*Redigobius dewaali* (Checked Goby)	N-End	Kny-Ext
Pisces	Gobiidae	*Silhouettea sibayi* (Sibayi Goby)	End	M
Pisces	Mochokidae	*Chiloglanis anoterus* (Pennant-tailed Suckermouth)	End	M
Pisces	Mochokidae	*Chiloglanis bifurcus* (Incomati Suckermouth)	N-End	EE
Pisces	Mugilidae	*Myxus capensis* (Freshwater Mullet)	N-End	Kny-Ext
Amphibia	Arthroleptidae	*Arthroleptis wahlbergi* (Bush Squeaker)	End	SEC (M-KZN)
Amphibia	Arthroleptidae	*Leptopelis natalensis* (Natal Tree Frog)	End	SEC (KZN-CT)
Amphibia	Arthroleptidae	*Leptopelis xenodactylus* (Long-toed Tree Frog)	End	KZN
Amphibia	Breviceptidae	*Breviceps bagginsi* (Bilbo's Rain Frog)	End	KZN
Amphibia	Breviceptidae	*Breviceps sopranos* (Whistling Rain Frog)	End	M
Amphibia	Breviceptidae	*Breviceps sylvestirs* (Northern Forest Rain Frog)	M-Out	EE
Amphibia	Breviceptidae	*Breviceps verrucosus* (Plaintive Rain Frog)	N-End	Esc-Ext
Amphibia	Bufonidae	*Amietophrynus pardalis* (Eastern Leopard Toad)	N-End	Kny-Ext
Amphibia	Bufonidae	*Vandijkophrynus amatolicus* (Amatola Toad)	End	AWS
Amphibia	Heleophrynidae	*Hadromophryne natalensis* (Natal Cascade Frog)	N-End	Esc-Ext
Amphibia	Hemisotidae	*Hemisus guttatus* (Spotted Shovel-nosed Frog)	N-End	Esc-Ext
Amphibia	Hyperoliidae	*Afrixalus aureus* (Golden Leaf-folding Frog)	N-End	Inh&Mop-Ext
Amphibia	Hyperoliidae	*Afrixalus spinifrons* (Natal Leaf-folding Frog)	End	SEC (KZN-CT)
Amphibia	Hyperoliidae	*Hyperolius pickersgilli* (Pickersgill's Reed Frog)	End	KZN
Amphibia	Hyperoliidae	*Hyperolius semidiscus* (Yellow-striped Reed Frog)	N-End	Esc-Ext
Amphibia	Pyxicephalidae	*Amietia dracomontana* (Drakensberg River Frog)	M-Out	D
Amphibia	Pyxicephalidae	*Amietia umbraculata* (Maluti River Frog)	M-Out	D
Amphibia	Pyxicephalidae	*Amietia vertebralis* (Phofung River Frog)	M-Out	D
Amphibia	Pyxicephalidae	*Anhydrophryne hewitti* (Natal Chirping Frog)	End	KZN
Amphibia	Pyxicephalidae	*Anhydrophryne ngongoniensis* (Mistbelt Chirping Frog)	End	KZN
Amphibia	Pyxicephalidae	*Anhydrophryne rattrayi* (Hogsback Chirping Frog)	End	Esc-Ext
Amphibia	Pyxicephalidae	*Cacosternum nanum* (Bronze Caco)	N-End	Esc&Kny-Ext
Amphibia	Pyxicephalidae	*Cacosternum parvum* (Mountain Caco)	Ext-Out	SEE (EE-D)
Amphibia	Pyxicephalidae	*Cacosternum poyntoni* (Poynton's Caco)	End	KZN
Amphibia	Pyxicephalidae	*Cacosternum* sp. nov. 'A' (Rhythmic Caco)	End	KZN
Amphibia	Pyxicephalidae	*Cacosternum* sp. nov. 'B' (KwaZulu Caco)	End	KZN
Amphibia	Pyxicephalidae	*Cacosternum striatum* (Striped Caco)	End	KZN
Amphibia	Pyxicephalidae	*Natalobatrachus bonebergi* (Kloof Frog)	End	SEC (KZN-CT)
Amphibia	Pyxicephalidae	*Strongylopus wageri* (Plain Stream Frog)	N-End	Esc-Ext
Reptilia	Amphisbaenidae	*Zygaspis violacea* (Violet Dwarf Worm Lizard)	N-End	Inh&Mop-Ext
Reptilia	Atractaspididae	*Amblyodipsas concolor* (Natal Purple-glossed Snake)	N-End	Esc-Ext
Reptilia	Atractaspididae	*Amblyodipsas microphthalma* (Eyeless Purple-glossed Snake)	N-End	Inh&Mop-Ext
Reptilia	Atractaspididae	*Aparallactus nigriceps* (Mozambique Centipede-eater)	Ext-Out	Inh&Mop-Ext
Reptilia	Atractaspididae	*Macrelaps microlepidotus* (Natal Black Snake)	End	SEC (M-KZN-CT)

[a], Status within the Maputaland-Pondoland-Albany (MPA) hotspot: End, endemic to MPA; N-End, near endemic to MPA (≥ 50% of the range inside MPA, see text for the definition); Ext-out, extending out from MPA (> 50% of the range outside MPA); M-Out, marginally outside MPA; Out, outside MPA. Eight additional MPA hotspot near endemics that are not endemic to the GMPA region are not listed above: *Bradypterus barratti* (Barratt's warbler), *Promerops gurneyi* (Gurney's sugarbird), *Amphilius natalensis* (Natal mountain catfish), *Afrotyphlops fornasinii* (Fornasini's worm snake), *Typhlosaurus aurantiacus* (golden blind legless skink), *Xenocalamus transvaalensis* (speckled quill-snouted snake), *Chiloglanis emarginatus* (Phongolo suckermouth) and *Otomys laminatus* (laminate vlei rat).

[b], Endemic vertebrate distributions (EVDs): SEC, South-eastern Coastal; M, Maputaland; KZN, KwaZulu-Natal; TCB, Transkei Coastal Belt; ACB, Albany Coastal Belt; Esc-Ext, South-eastern Escarpment Extension of SEC; Kny-Ext, Knysna Extension of SEC; Esc&Kny-Ext, South-eastern Escarpment and Knysna Extension of SEC; Inh&Mop-Ext, Inhambane and Mopane Extension of SEC; SEE, South-eastern Escarpment; EE, Eastern Escarpment; D, Drakensberg; AWS, Amatola-Winterberg-Sneeuberg; Ext-A&C, Extended South-eastern Afromontane and Coastal; SE-Africa, South-eastern Africa; SE-SAfrica, South-east of South Africa (Figure 1).

Appendix 1 continues on the next page →

APPENDIX 1: Endemic vertebrates of the Greater Maputaland-Pondoland-Albany (GMPA) region

Class	Family	Species	Status within MPA hotspot[a]	Representation in EVDs[b]
Reptilia	Chamaeleonidae	*Bradypodion caeruleogula* (uMlalazi Dwarf Chameleon)	End	KZN
Reptilia	Chamaeleonidae	*Bradypodion caffer* (Pondo Dwarf Chameleon)	End	TCB
Reptilia	Chamaeleonidae	*Bradypodion dracomontanum* (Drakensberg Dwarf Chameleon)	M-Out	D
Reptilia	Chamaeleonidae	*Bradypodion kentanicum* (Kentani Dwarf Chameleon)	End	TCB
Reptilia	Chamaeleonidae	*Bradypodion melanocephalum* (KwaZulu Dwarf Chameleon)	End	KZN
Reptilia	Chamaeleonidae	*Bradypodion nemorale* (Qudeni Dwarf Chameleon)	End	KZN
Reptilia	Chamaeleonidae	*Bradypodion ngomeense* (Ngome Dwarf Chameleon)	End	KZN
Reptilia	Chamaeleonidae	*Bradypodion setaroi* (Setaro's Dwarf Chameleon)	End	M
Reptilia	Chamaeleonidae	*Bradypodion* sp. nov. 'emerald' (Emerald Dwarf Chameleon)	M-Out	D
Reptilia	Chamaeleonidae	*Bradypodion thamnobates* (Natal Midlands Dwarf Chameleon)	End	KZN
Reptilia	Chamaeleonidae	*Bradypodion transvaalense* (Wolkberg Dwarf Chameleon)	M-Out	EE
Reptilia	Chamaeleonidae	*Bradypodion ventrale* (Eastern Cape Dwarf Chameleon)	N-End	Esc-Ext
Reptilia	Colubridae	*Dasypeltis inornata* (Southern Brown Egg Eater)	N-End	Esc-Ext
Reptilia	Cordylidae	*Cordylus tasmani* (Tasman's Girdled Lizard)	End	ACB
Reptilia	Cordylidae	*Cordylus warreni* (Warren's Girdled Lizard)	Ext-Out	EE
Reptilia	Cordylidae	*Platysaurus lebomboensis* (Lebombo Flat Lizard)	End	M
Reptilia	Cordylidae	*Platysaurus orientalis* (Sekhukhune Flat Lizard)	M-Out	EE
Reptilia	Cordylidae	*Platysaurus relictus* (Soutpansberg Flat Lizard)	Out	EE
Reptilia	Cordylidae	*Pseudocordylus langi* (Lang's Crag Lizard)	M-Out	D
Reptilia	Cordylidae	*Pseudocordylus spinosus* (Spiny Crag Lizard)	N-End	D
Reptilia	Gekkonidae	*Afroedura amatolica* (Amatola Flat Gecko)	End	AWS
Reptilia	Gekkonidae	*Afroedura halli* (Hall's Flat Gecko)	M-Out	D
Reptilia	Gekkonidae	*Afroedura karroica* (Karoo Flat Gecko)	N-End	AWS
Reptilia	Gekkonidae	*Afroedura langi* (Lowveld Flat Gecko)	N-End	Inh&Mop-Ext
Reptilia	Gekkonidae	*Afroedura major* (Giant Swazi Flat Gecko)	N-End	EE
Reptilia	Gekkonidae	*Afroedura marleyi* (Marley's Flat Gecko)	End	M
Reptilia	Gekkonidae	*Afroedura multiporis* (Woodbush Flat Gecko)	M-Out	EE
Reptilia	Gekkonidae	*Afroedura nivaria* (Drakensberg Flat Gecko)	M-Out	D
Reptilia	Gekkonidae	*Afroedura pondolia* (Pondo Flat Gecko)	End	SEC (KZN-CT)
Reptilia	Gekkonidae	*Afroedura* sp. nov. 'granitica'	N-End	EE
Reptilia	Gekkonidae	*Afroedura* sp. nov. 'lebomboensis'	End	EE
Reptilia	Gekkonidae	*Afroedura* sp. nov. 'leoleonsis'	Out	EE
Reptilia	Gekkonidae	*Afroedura* sp. nov. 'mariepi'	N-End	EE
Reptilia	Gekkonidae	*Afroedura* sp. nov. 'pongolae'	End	EE
Reptilia	Gekkonidae	*Afroedura* sp. nov. 'rondavelica'	N-End	EE
Reptilia	Gekkonidae	*Afroedura* sp. nov. 'rupestris'	N-End	EE
Reptilia	Gekkonidae	*Afroedura tembulica* (Tembo Flat Gecko)	End	AWS
Reptilia	Gekkonidae	*Goggia essexi* (Essex's Pygmy Gecko)	End	ACB
Reptilia	Gekkonidae	*Lygodactylus methueni* (Methuen's Dwarf Gecko)	Out	EE
Reptilia	Gerrhosauridae	*Tetradactylus africanus* (Eastern Long-tailed Seps)	N-End	Esc-Ext
Reptilia	Gerrhosauridae	*Tetradactylus eastwoodae* (Eastwood's Long-tailed Seps)	Out	EE
Reptilia	Lacertidae	*Australolacerta rupicola* (Soutpansberg Rock Lizard)	Out	EE
Reptilia	Lacertidae	*Nucras taeniolata* (Striped Scrub Lizard)	End	ACB
Reptilia	Lacertidae	*Tropidosaura cottrelli* (Cottrell's Mountain Lizard)	M-Out	D
Reptilia	Lacertidae	*Tropidosaura essexi* (Essex's Mountain Lizard)	M-Out	D
Reptilia	Lamprophiidae	*Inyoka swazicus* (Swazi Rock Snake)	M-Out	EE
Reptilia	Lamprophiidae	*Lycodonomorphus laevissimus* (Dusky-bellied Water Snake)	N-End	Esc-Ext
Reptilia	Lamprophiidae	*Lycophidion pygmaeum* (Pygmy Wolf Snake)	End	M
Reptilia	Lamprophiidae	*Lycophidion semiannule* (Bazaruto Wolf Snake)	N-End	Inh&Mop-Ext
Reptilia	Leptotyphlopidae	*Leptotyphlops sylvicolus* (Forest Thread Snake)	End	SEC (M-KZN-CT)
Reptilia	Leptotyphlopidae	*Leptotyphlops telloi* (Tello's Thread Snake)	End	M
Reptilia	Prosymnidae	*Prosymna janii* (Mozambique Shovel-snout)	N-End	Inh&Mop-Ext
Reptilia	Pseudoxyrhophiidae	*Duberria variegate* (Variegated Slug-eater)	N-End	Inh&Mop-Ext
Reptilia	Pseudoxyrhophiidae	*Montaspis gilvomaculata* (Cream-spotted Mountain Snake)	M-Out	D
Reptilia	Scincidae	*Acontias breviceps* (Short-headed Legless Skink)	N-End	SEE (EE-D-AWS)
Reptilia	Scincidae	*Acontias poecilus* (Variable Legless Skink)	End	TCB

[a], Status within the Maputaland-Pondoland-Albany (MPA) hotspot: End, endemic to MPA; N-End, near endemic to MPA (≥ 50% of the range inside MPA, see text for the definition); Ext-out, extending out from MPA (> 50% of the range outside MPA); M-Out, marginally outside MPA; Out, outside MPA. Eight additional MPA hotspot near endemics that are not endemic to the GMPA region are not listed above: *Bradypterus barratti* (Barratt's warbler), *Promerops gurneyi* (Gurney's sugarbird), *Amphilius natalensis* (Natal mountain catfish), *Afrotyphlops fornasinii* (Fornasini's worm snake), *Typhlosaurus aurantiacus* (golden blind legless skink), *Xenocalamus transvaalensis* (speckled quill-snouted snake), *Chiloglanis emarginatus* (Phongolo suckermouth) and *Otomys laminatus* (laminate vlei rat).

[b], Endemic vertebrate distributions (EVDs): SEC, South-eastern Coastal; M, Maputaland; KZN, KwaZulu-Natal; TCB, Transkei Coastal Belt; ACB, Albany Coastal Belt; Esc-Ext, South-eastern Escarpment Extension of SEC; Kny-Ext, Knysna Extension of SEC; Esc&Kny-Ext, South-eastern Escarpment and Knysna Extension of SEC; Inh&Mop-Ext, Inhambane and Mopane Extension of SEC; SEE, South-eastern Escarpment; EE, Eastern Escarpment; D, Drakensberg; AWS, Amatola-Winterberg-Sneeuberg; Ext-A&C, Extended South-eastern Afromontane and Coastal; SE-Africa, South-eastern Africa; SE-SAfrica, South-east of South Africa (Figure 1).

Appendix 1 continues on the next page →

APPENDIX 1: Endemic vertebrates of the Greater Maputaland-Pondoland-Albany (GMPA) region

Class	Family	Species	Status within MPA hotspot[a]	Representation in EVDs[b]
Reptilia	Scincidae	*Acontophiops lineatus* (Woodbush Legless Skink)	Out	EE
Reptilia	Scincidae	*Scelotes anguineus* (Algoa Dwarf Burrowing Skink)	End	ACB
Reptilia	Scincidae	*Scelotes arenicolus* (Zululand Dwarf Burrowing Skink)	End	M
Reptilia	Scincidae	*Scelotes bidigittatus* (Lowveld Dwarf Burrowing Skink)	N-End	Inh&Mop-Ext
Reptilia	Scincidae	*Scelotes bourquini* (Bourquin's Dwarf Burrowing Skink)	End	KZN
Reptilia	Scincidae	*Scelotes fitzsimonsi* (FitzSimons' Dwarf Burrowing Skink)	End	M
Reptilia	Scincidae	*Scelotes guentheri* (Guenthers' Dwarf Burrowing Skink)	End	KZN
Reptilia	Scincidae	*Scelotes inornatus* (Durban Dwarf Burrowing Skink)	End	KZN
Reptilia	Scincidae	*Scelotes mirus* (Montane Dwarf Burrowing Skink)	N-End	EE
Reptilia	Scincidae	*Scelotes mossambicus* (Mozambique Dwarf Burrowing Skink)	N-End	Esc-Ext
Reptilia	Scincidae	*Scelotes vestigifer* (Coastal Dwarf Burrowing Skink)	End	M
Reptilia	Testudinidae	*Kinixys natalensis* (Natal Hinged Tortoise)	End	Esc-Ext
Reptilia	Viperidae	*Bitis albanica* (Albany Adder)	End	ACB
Reptilia	Viperidae	*Bitis inornata* (Plain Mountain Adder)	End	AWS
Aves	Accipitridae	*Buteo trizonatus* (Forest Buzzard)	N-End	Esc&Kny-Ext
Aves	Alaudidae	*Heteromirafra ruddi* (Rudd's Lark)	Ext-Out	SEE (EE-D)
Aves	Chaetopidae	*Chaetops aurantius* (Drakensberg Rock-jumper)	N-End	SEE (D-AWS)
Aves	Cisticolidae	*Prinia hypoxantha* (Drakensberg Prinia)	N-End	Esc-Ext
Aves	Fringillidae	*Crithagra scotops* (Forest Canary)	N-End	Esc&Kny-Ext
Aves	Fringillidae	*Crithagra symonsi* (Drakensberg Siskin)	M-Out	D
Aves	Megaluridae	*Bradypterus sylvaticus* (Knysna Warbler)	N-End	Kny-Ext
Aves	Motacillidae	*Anthus chloris* (Yellow-breasted Pipit)	N-End	SEE (EE-D)
Aves	Motacillidae	*Anthus hoeschi* (Mountain Pipit)	M-Out	D
Aves	Muscicapidae	*Cossypha dichroa* (Chorister Robin-Chat)	N-End	Esc&Kny-Ext
Aves	Muscicapidae	*Oenanthe bifasciata* (Buff-streaked Chat)	N-End	Esc-Ext
Aves	Musophagidae	*Tauraco corythaix* (Knysna Turaco)	N-End	Esc&Kny-Ext
Aves	Picidae	*Campethera notata* (Knysna Woodpecker)	N-End	Kny-Ext
Aves	Psittacidae	*Poicephalus robustus* (Cape Parrot)	N-End	Esc-Ext
Aves	Timaliidae	*Lioptilus nigricapillus* (Bush Blackcap)	N-End	Esc-Ext
Mammalia	Chrysochloridae	*Amblysomus hottentotus* (Hottentot Golden Mole)	N-End	Esc&Kny-Ext
Mammalia	Chrysochloridae	*Amblysomus marleyi* (Marley's Golden Mole)	End	M
Mammalia	Chrysochloridae	*Amblysomus robustus* (Robust Golden Mole)	Out	EE
Mammalia	Chrysochloridae	*Chrysospalax trevelyani* (Giant Golden Mole)	End	TCB
Mammalia	Chrysochloridae	*Neamblysomus gunningi* (Gunning's Golden Mole)	Out	EE
Mammalia	Leporidae	*Pronolagus crassicaudatus* (Natal Red Rock Rabbit)	N-End	Esc-Ext
Mammalia	Muridae	*Otomys sloggetti* (Sloggett's Vlei Rat)	Ext-Out	SEE (EE-D)
Mammalia	Soricidae	*Myosorex sclateri* (Sclater's Forest Shrew)	End	SEC (M-KZN)

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[b], Endemic vertebrate distributions (EVDs): SEC, South-eastern Coastal; M, Maputaland; KZN, KwaZulu-Natal; TCB, Transkei Coastal Belt; ACB, Albany Coastal Belt; Esc-Ext, South-eastern Escarpment Extension of SEC; Kny-Ext, Knysna Extension of SEC; Esc&Kny-Ext, South-eastern Escarpment and Knysna Extension of SEC; Inh&Mop-Ext, Inhambane and Mopane Extension of SEC; SEE, South-eastern Escarpment; EE, Eastern Escarpment; D, Drakensberg; AWS, Amatola-Winterberg-Sneeuberg; Ext-A&C, Extended South-eastern Afromontane and Coastal; SE-Africa, South-eastern Africa; SE-SAfrica, South-east of South Africa (Figure 1).