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THE SPECIES DIVERSITY, DISTRIBUTION AND CONSERVATION OF NAMIBIAN REPTILES: A REVIEW

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ABSTRACT

A brief historical chronology of Namibian reptile research is given. Namibia's extant fauna of ~ 258 species represents approximately 53% of the Southern African Subregion's species richness, 79% of generic richness, and 100% of the region's familial richness. Sixty-six species are presently recognized as endemic (75% or more of total population range). These endemics occur predominantly in the Namib desert, pro-Namib and adjoining inland escarpment, and are primarily rupicolous. The Namibian endemic reptile fauna is characterised by the speciose genera *Pachydactylus, Rhoptropus* and *Ptenopus* (Gekkonidae), *Meroles* and *Pedioplanis* (Lacertidae) and the Scincidae as well as the Cordylidae have also speciated extensively.

Approximately 67% of all Namibian species are provisionally regarded to be "Secure". However, due to a paucity of data, 60 species (25%) are assigned to possible or probable threat categories. Seven species are considered to be "Vulnerable".

Approximately 13% of the Namibian landscape is set aside for preservation purposes. Approximately 90% of the reptile fauna is represented within the formal protection network, ~65% of all species occur in three or more reserves and ~23% occur in 10 or more reserves.

Over-collecting (and gathering) and the alteration of habitat (wetlands as well as rupicolous substrates) are identified as conservation issues.

INTRODUCTION

History remembers Johan Wahlberg as an early Namibian explorer, who, nearly two years after landing in Walvis Bay in 1854, was killed by an elephant bull near Lake Ngami. Although not the first naturalist/explorer to travel through Namibia (he was preceded by, amongst others, Le Vaillant, Alexander, and Andersson), nor among the first to have an unfortunate encounter with local wildlife; George Bonfield, for instance, was knocked into the Kavango River by a hippo, and then immediately

eaten by a crocodile), Wahlberg is remembered by herpetologists as the first systematic collector of Namibian reptiles. Before falling victim to the elephant, he amassed a collection representing 45 indigenous species.

This collection went to the natural history museum in Berlin, and for the next 70 years German museums and German taxonomists dominated the field of Namibian reptile research. Although not in a dominant position today, German museums still hold perhaps 30% of all available study material, and German scientists regularly publish on indigenous Namibian species.

In the 1920s, South African museums, especially the Transvaal Museum, and zoologists started taking a greater interest in the territory. The era of monographing of taxonomic groups and regions followed shortly. FitzSimons' *"The Lizards of South Africa"* (1943) included the territory of South West Africa, and Loveridge's taxonomic revisions included Namibia as part of their continental perspective (e.g. Loveridge, 1941).

The first modern regional account, an annotated checklist which did not include the Caprivi, was published in 1955 by Robert Mertens after spending two months in the South West Africa mandate in 1952. FitzSimons' *Snakes of Southern Africa* appeared in 1962, by which time the Southern African subregional treatment was well established. During the 1950s and 60s major additions to the understanding of Namibian reptiles were published, and Mertens, in an attempt to keep up with these changes, published a revised annotated checklist in 1971, 16 years after the first one (but still not including the Caprivi strip). In 1988, the Namibian reptile fauna was included in a multi-authored Provisional and Annotated Checklist of the Herpetofauna of the Southern African Subregion (Branch (ed), 1988a).

The Southern African region has become a centre of outstanding reptile research, undoubtedly the most active and prolific region on the continent. The Herpetological Association of Africa, spawned from the old Herpetological Association of Rhodesia, was founded in 1965 (Broadley, 1996), with over 90% of the publications in the society's journal (now the African Journal of Herpetology, changed from the Journal of the Herpetological Association of Africa in 1996) originating from the subregion. Popular literature, catering specially for the subregion's amateur reptile enthusiasts, has proliferated (e.g. Patterson & Bannister, 1987; Branch, 1988b; Marais, 1992; and Branch, 1993). FitzSimons' *Snakes of Southern Africa* is now undergoing its third revision (Broadley, 1983; 1990), and FitzSimons' *Lizards of South Africa* is now being revised completely.

Non-Namibians have conducted the majority of past research, and today are still prominent in this scene. For instance, the National Museum of Namibia (previously the State museum) has had a professional full-time herpetologist in-residence for only four of the past 35 years, and the local conservation authority has never employed a full-time herpetologist. While the National Collection (NMWN) today houses approximately 12 000 reptile specimens, representing over 75% of the national species richness, only eight species out of a possible 78 species are represented by primary

type material (R E Griffin, pers.comm.). Recent national policy directed at encouraging foreign researchers to deposit a proportion of their collections, including any new type material in the National Museum has been relatively successful. The reptile collection is fully curated, is reasonably active (five to seven loans/year) and is currently growing at the rate of 200-400 specimens annually. The Ministry of Environment and Tourism is the largest donor. Despite the lack of institutional support for home-grown herpetologists, the state of Namibian reptile research is not far behind the rest of the subregion. Therefore, and in retrospect, Namibian herpetology has benefited tremendously due to its past colonial affinities, as well as to its strategic position within the Southern African subregion, which is a conveniently-shaped landmass unit for biogeographical studies.

MATERIALS AND METHODS

Data on Namibian reptiles are available from approximately 35 000 museum specimens housed in Namibian, South African, German, North American, Austrian and British museums (in descending order of holdings). Local Postal questionnaire surveys are of limited value, but have yielded useful information in respect to some easily recognized species e.g. pythons (Branch & Griffin, 1996), tortoises, pythons and monitor lizards (Griffin & Kolberg, in prep.), tortoises (Griffin & Clark, unpublished data), and crocodiles. Anecdotal information from amateur reptile enthusiasts can be useful if viewed with caution, and specimens opportunistically collected by amateurs, especially in earlier years, made significant contributions to the existing body of knowledge. The effectiveness of amateur input into the data-gathering process is midway between ornithology, where amateur bird watchers provide a major proportion of useful data, and mammals, where amateur input is practically nil. An annotated bibliography of Namibian herpetology is being compiled (Griffin, in prep.), and the preliminary search lists approximately 1 100 titles relating directly to the Namibian situation, the large majority related primarily to reptiles.

Despite what would seem to be an extensive data base, there is still a severe paucity of relevant data on many Namibian species. Taxonomic problems are slowly being resolved, through both traditional morphometric methods, as well as modern biochemical techniques and biogeographical patterns are fine-tuned regularly. Still, many species are known from only a few museum specimens, collected long ago in widely spaced localities. Conservation status rankings given in this report, for the majority of species, are therefore entirely provisional. As little directly-relevant data are available, categories have been subjectively assigned. The species-richness maps, figures 1-10 (which, considering the paucity of data in many cases, should be regarded as predicted-potential species-richness) were generated by overlaying individual hand-drawn range maps, which were themselves roughly delineated, using a combination of the above data sources, the results of unpublished and ongoing fieldwork, extrapolation, intuition, and inference.

RESULTS

DIVERSITY

Griffin (1999) lists 258 species which are currently known or expected to occur in Namibia. These

taxa represent 53% of the subregions's species richness, 79% of generic richness, and 100% of familial richness (Namibias 824 392 km^2. is roughly 1/4 of the subregion's surface area). From the continental perspective, Namibia has representatives of ~30% of the species richness 55% of generic richness, and 91% of familial richness (table 1 and appendix 1). In addition, with 125 species of Lacertilia, Namibia has one of the richest lizard faunas on the continent.

BIOGEOGRAPHY

Figure 1 illustrates the expected potential numerical distribution of 236 species of Namibian reptiles. As most Namibian species are terrestrial, substrate, and habitat specific, figure 1 is also a reflection of habitat and substrate diversity, as well as potential species richness.

No thorough biogeographical analysis of Namibian reptiles has been published to date. Haacke (1984), however, discussed the fauna of the southern Kalahari domain, as did Pianka (1986), and its affinities with the central Kalahari and the Karoo and/or Namaqualand domain. In addition, a biogeographical analysis of Namib Desert herpetology (1 500 km of the 2 000 km-long desert is within Namibia) is nearing completion (Haacke, in prep.). Reptilia Zambeziaca, a major taxonomic/biogeographical analysis (Broadley, in prep), will include the Caprivi Strip within the study area, while a monographic treatment of Namibian lizards is also currently underway (Griffin, in prep).

Expected potential species-richness maps are given for non-marine Chelonians (figure 2), Squamata (figure 3), Amphisbaenids (figure 4), and Serpentes (figure 5).

Basic patterns of reptile distributions in Namibia are correlated strongly with physiographic features. Griffin and Channing (1991) summarised the occurrence and distribution of wetland-related reptiles in Namibia. Highest species-richness occurred in the Caprivi where the Okavango, Kwando-Chobe, and Zambezi rivers provide the required habitat for (e.g.) terrapins (*Pelusios* sp.) and aquatic snakes and other aquatic reptiles. Only water monitors (*Varanus niloticus*) and helmeted terrapins (*Pelomedusa subrufa*) occur in the Orange and Fish rivers, while apparently crocodiles (*Crocodylus niloticus*) have not occurred there during historic times. The Kunene River, like the Caprivi rivers, drains through reptile-rich faunas of the north, but thus far the Nile crocodile, water monitor, the African softshelled turtle (*Trionyx triunguis*) are the only aquatic reptiles known from this potentially rich wetland habitat. Green water snakes (probably *Philothamnus* sp.) are reported, but not confirmed, from the Kunene.

The mouth of the Kunene is an aggregation point for non-breeding Green turtles (*Chelonia mydas*), and at times as many as 200 have been observed at one time. This aggregation is probably due to the relatively warmer water of the river providing a haven from the cold Benguela Current. The only Namibian population of African softshelled turtles is restricted to the mouth and a few km inland. It is disjunct and is the southern-most population of this wide ranging species.

Rivers are generally not good biogeographical barriers in Namibia. The distributions of approximately 20 species are seemingly limited by rivers, but this may be largely an artifact of sampling in-

TABLE 1

EVOLUTIONARY DIVERSITY OF INDIGENOUS NAMIBIAN REPTILES: IN SUBREGIONAL, CONTINENTAL AND GLOBAL PERSPECTIVE

TAXA	NAMIBIAN	SOUTHERN AFRICAN SUBREGION	ETHIOPIAN	GLOBAL
SPECIES	~258	[illegible]	-	6550
GENERA	88	113	~215	905
FAMILIES	22	22	26	48
ORDERS	3	3	3	4

tensity. This situation is most apparent with the Kunene and Orange rivers, both perennial Namib desert-crossing rivers. Both rivers, however have extremely reduced flow at times, the mouths temporarily silting up and the streams themselves breaking up into semi-connected pools of water. At these times, these rivers are barriers to only the most sedentary of species (Haacke, 1982). Even during periods of relatively high water in the Kunene, highly active species, for instance diurnal damara rock agamas (*Agama planiceps*), can be seen rock-hopping across the river between Namibia and Angola.

Western Namibia, dominated by the Namib Desert (ranging in width from 50-150 km), pro-Namib (some authors refer to this as Nama-Karoo), and adjacent escarpment, is a mosaic of habitats, often with sharp boundaries resulting in disjunct and atypical populations (Seely & Griffin, 1986). The two major sand seas (one in the central and south and the other in the north) are separated by 290 km of gravel plains, bordered on the west by nearly continuous coastal dune hummocks, interspersed with sheet rock and rupicolous habitats (inselbergs) and crossed by dry river courses. The sand seas are also intruded by perennial rivers, with associated riparian vegetation, creating linear oases. Inselbergs, found throughout the sand seas and gravel plains, provide further specialised habitat, and associated disjunct populations within these otherwise locally-uniform landscapes. Approximately 60 species (~25% of all species and ~15% of all Namibian endemics) are endemic to or found predominately in the Namibian portion of the Namib Desert biome (figure 8).

Following the green turtle, which is most common north of the 22° longitude, the leatherback turtle (*Dermochelys coriacea*) is the second most frequently encountered marine turtle in Namibia. Most of these turtles are found along the central Namibian coast, between 22° and 23° S. Two other marine species occur as rare vagrants. Despite some questionable historical records (e.g. Morrell, [illegible]44) there is no evidence that sea turtles have nested in Namibia during recent times.

The pelagic sea snake (*Pelamis platurus*) has recently been recorded from the central Namibian coast, and a green turtle, tagged on Europa island, in the Mozambique channel was recovered from the central Namibian coast in 1992. These occurrences demonstrate the occasional linkage of the warm Indian Ocean fauna via the Agulhas current to the cold Benguela current.

ENDEMISM

Sixty-six species (26%) of Namibian reptiles are currently defined as endemic (see Appendix 2 for definition). Lizards,w with ~35% endemism within the national fauna, show the greatest diversity, followed by snakes (16 species, ~12% rate within the order, and ~4% of all Namibian reptiles), and one tortoise (one out of six species).

Within the Sauria, the Gekkonidae (especially the genus *Pachydactylus*,), the Lacertidae (especially the genera *Meroles* and *Pedioplanis*), and the Scincidae and Cordylidae have extensively speciated locally and regionally. Figure 6 illustrates the estimated and superimposed potential distribution of Namibian endemic lizards. Lizard genera (*Narudasia, Rhoptropus, Ptenopus, Meroles, Pedioplanis, Cordylosaurus, Typhlacotias and Palmatogecko*, including *Kaokogecko*) are essentially endemic or

Figure 1 - Expected potential distribution of 236 indigenous Namibian reptiles.

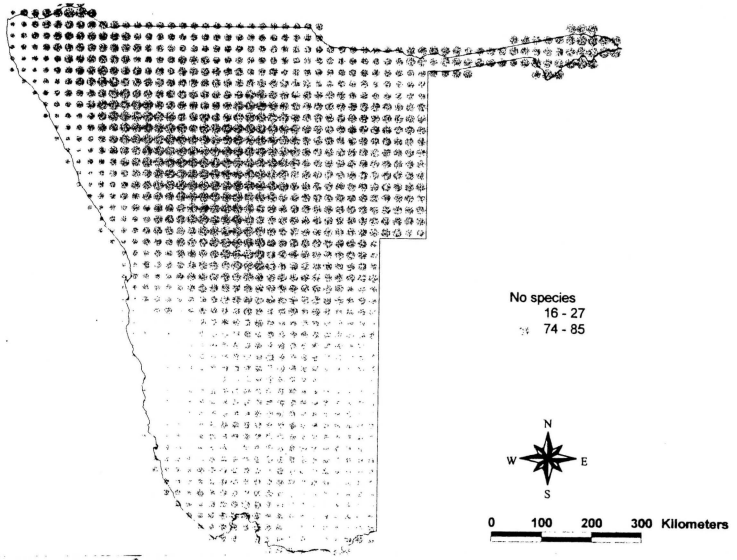


Figure 2 - Expected potential distribution of 12 indigenous Namibian chelonians.

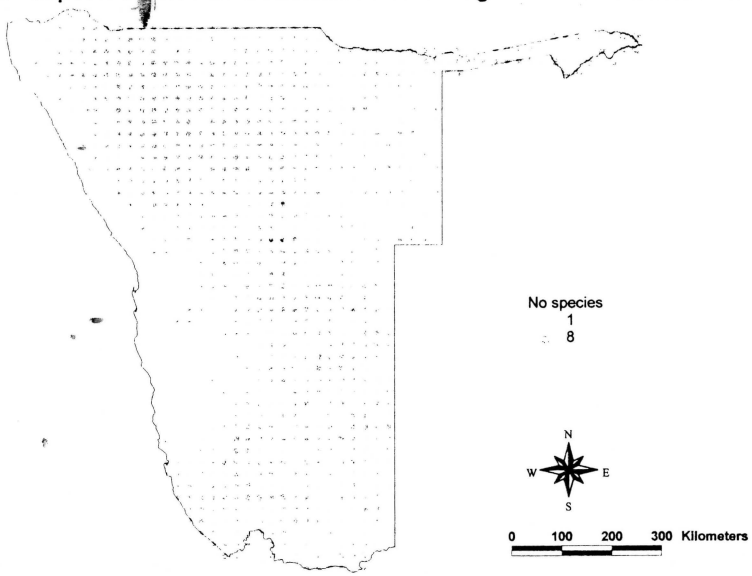


Figure 3 - Expected potential distribution of 125 indigenous Namibian lizards.

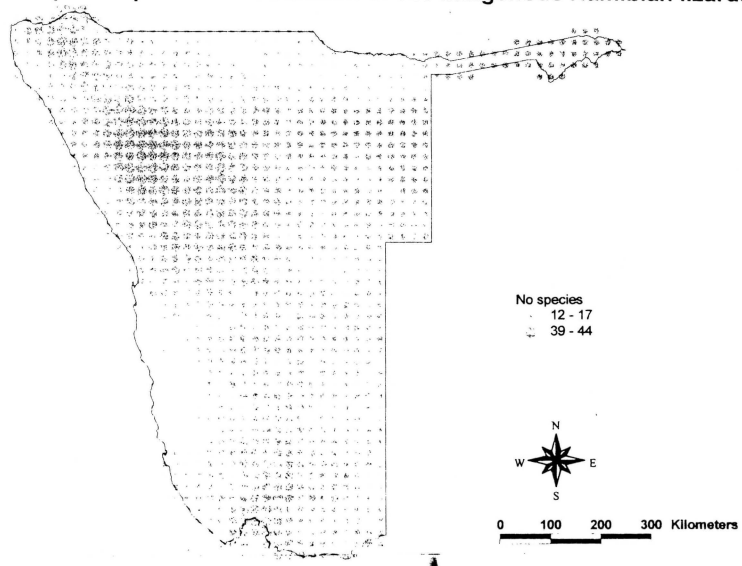


Figure 4 - Expected potential distribution of 8 indigenous Namibian amphisbaenids

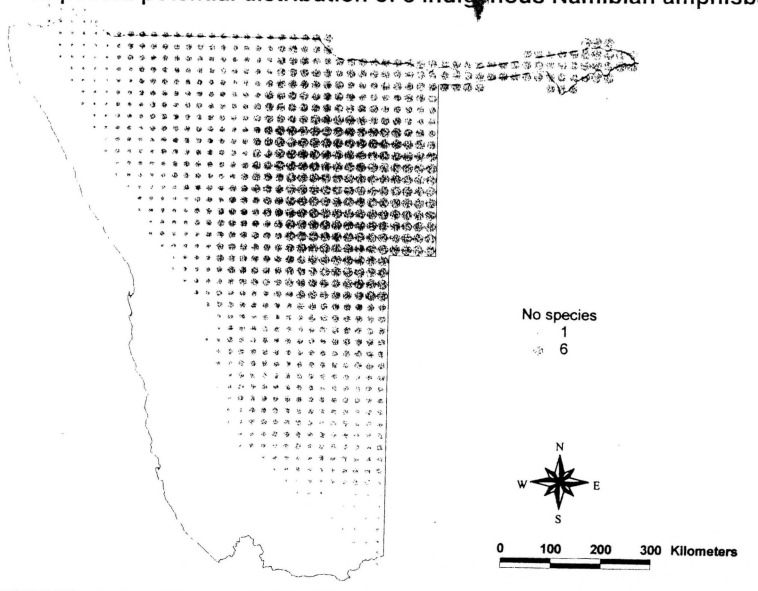


Figure 5 - Expected potential distribution of 89 indigenous Namibian snakes

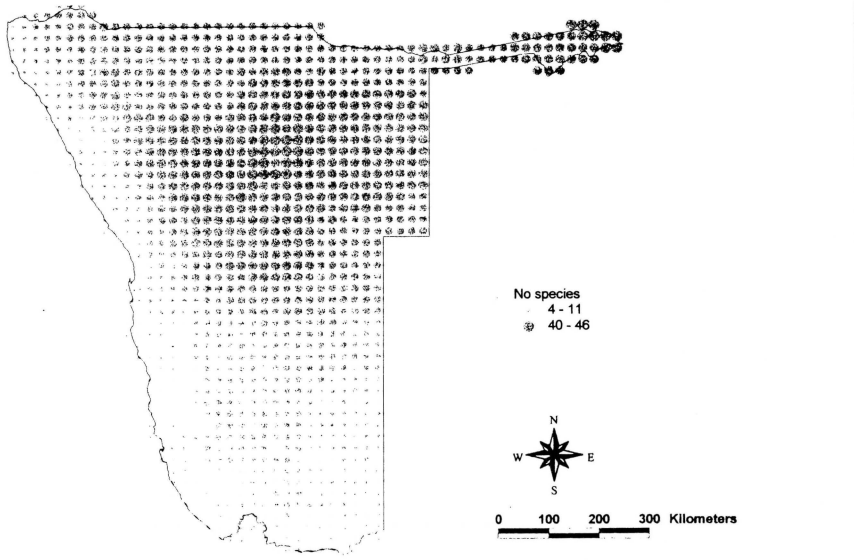


Figure 6 - Expected potential distribution of 49 endemic Namibian lizards

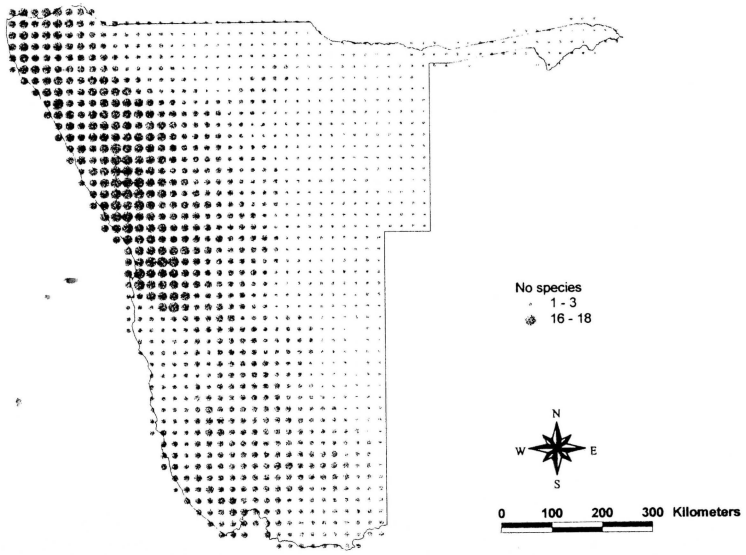


Figure 7 - Expected potential distribution of 16 endemic Namibian snakes

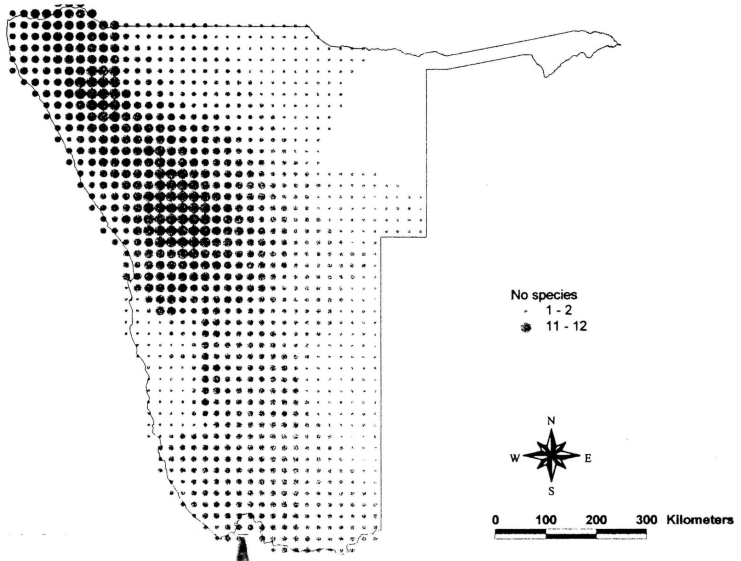


Figure 8 - Expected potential distribution of 66 endemic Namibian reptiles

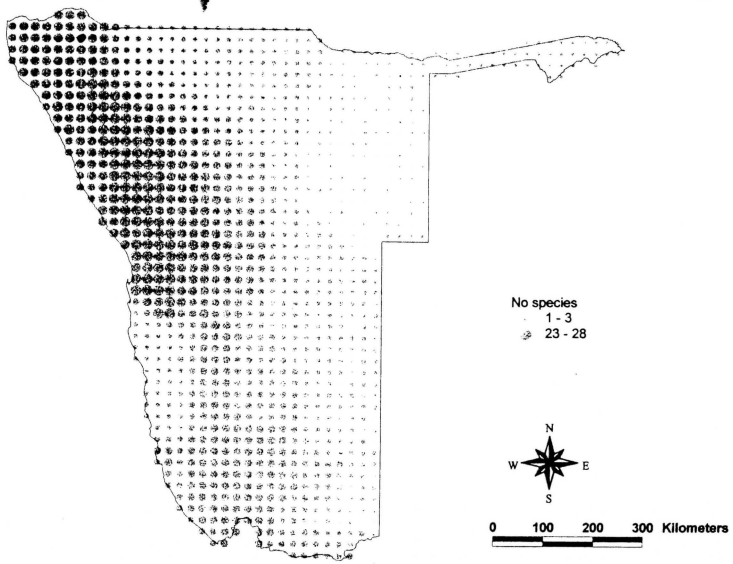


Figure 9 - Expected potential distribution of 152 Namibian reptiles of conservation concern

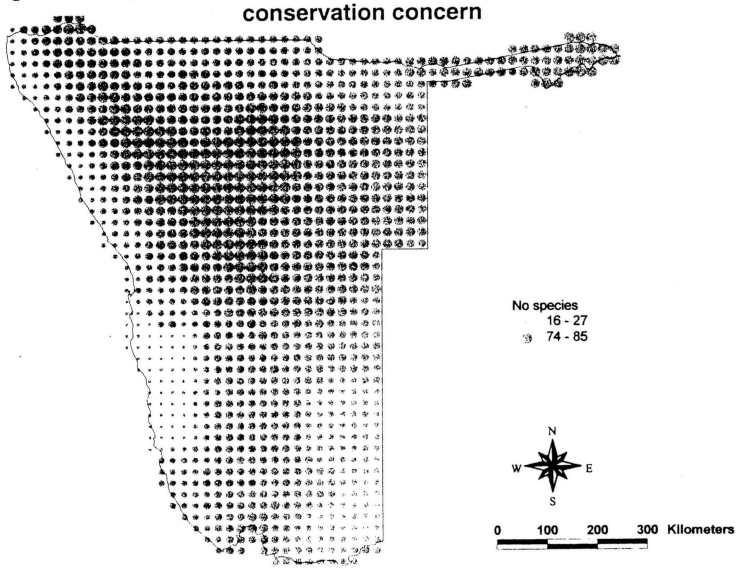
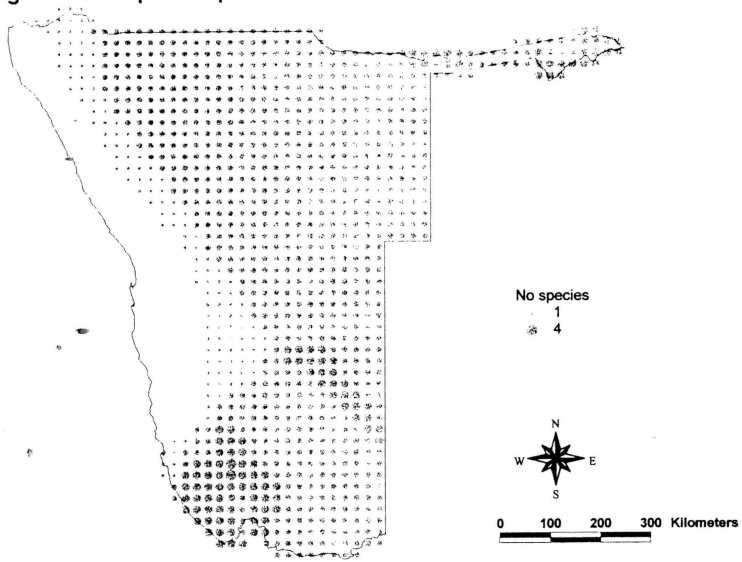


Figure 10 - Expected potential distribution of 6 Namibian tortoises



show greatest species radiation in Namibia. Figure 7 illustrates the predicted and superimposed potential distribution of 16 species of endemic Namibian snakes. This fauna displays less generic specialisation than lizards, and is spread throughout the systematic spectrum of African snakes i.e. one boid, two leptotyphlopids, one typhlopid, four genera (and species) of colubrids, one elapid and two endemic dwarf adders (*Viperidae*). Only the snake genus Pythonodipsas can be regarded as endemic Namibian. The single endemic tortoise, the Nama padloper (*Homopus* sp. nov.) is the only Namibian representative of this essentially South African genus.

Figure 8 illustrates the superimposed and estimated distribution of all 66 species of endemic Namibian reptiles. This pattern of distribution is correlated primarily with the mosaic of major substrates in the Namib, pro-Namib, and adjacent escarpment: sand dunes, gravel plains, sheet rock and elevated rocky habitats.

CONSERVATION STATUS

The Red Data Book on Namibian reptiles (including amphibians) is in an advanced stage of preparation. As an interim source of information, Griffin (1999) has proposed provisional conservation-status rankings for all reptiles currently known or expected to occur in Namibia. Using these provisional rankings, the frequency of species occurring in all categories is given in Table 2. In addition, the expected and superimposed distribution of 152 species of "conservation concern" is given in figure 9.

About 67% of Namibian reptiles are currently thought to be of 'conservation concern' i.e. any ranking other than just 'Secure'. Seven species are assigned definite threat categories and a further 60 are assigned probable or possible threat categories (e.g. 'Indeterminate, 'Insufficiently Known', and 'Peripheral'). 'Rare' is not considered a definite threat category. The frequency of use of these transitional categories is an accurate reflection of the current state of knowledge. Few species are known so well that definite conservation status rankings can be assigned with any degree of confidence. In practice, assigning conservation status rankings to the large majority of Namibian reptiles is a highly subjective process. Most species (including those provisionally assessed as 'Secure') would be defined as 'Data Deficient' in the latest IUCN Red Data guidelines (IUCN, 1994). By definition, species in this category require a high degree of protection until the species can be assigned, with confidence to a definite category.

Direct over-utilization and habitat alteration are the two primary factors responsible for a reptile entering a threat category. For instance, in the early 1970s, crocodiles were over hunted (for their skins) in the northern rivers to a point which caused concern. However, through a programme of strict control, the situation has been reversed to the point where 'problem crocodiles' have to be removed regularly by local conservation staff. Since this time, the artificial farming of crocodiles has become a risky but potentially profitable business. On the other hand, this business can become a convenient outlet for illegally acquired skins/individuals, unless carefully controlled.

It is ironic, but understandable that Namibia's two previous colonial associates, formerly playing

TABLE 2

PROVISIONAL CONSERVATION STATUS OF INDIGENOUS NAMIBIAN REPTILES

NUMBER OF SPECIES PER FAMILY IN EACH CONSERVATION-STATUS CATEGORY
(A SPECIES MAY OCCUR IN MORE THAN ONE CATEGORY)

NAMIBIAN CONSERVATION STATUS CATEGORY	REPTILE FAMILIES: CROCODYLIDAE	PELOMEDUSIDAE	TESTUDINIDAE	CHELONIIDAE	DERMOCHELYIDAE	TRIONYCHIDAE	GEKKONIDAE	AGAMIDAE	CHAMAELEONIDAE	SCINCIDAE	LACERTIDAE	CORDYLIDAE	VARANIDAE	AMPHISBAENIDAE	LEPTOTYPHLOPIDAE	TYPHLOPIDAE	BOIDAE	COLUBRIDAE	ATRCTASPIDAE	ELAPIDAE	HYDROPHIIDAE	VIPERIDAE	TOTAL
ENDANGERED																							0
VULNERABLE			4										2				1						7
RARE							8	2	1	3	2	1		3	3	1		16	5	1	1	2	49
INDETERMINATE			1	2		1				1					2			2				9	
INSUFFICIENTLY KNOWN							2	2			2	3		1		1	1	9	4	1		3	29
ENDEMIC			1				24	1		7	11	6			2	1	1	9		1		2	66
PERIPHERAL	1	4	3	4	1	1	1				2	2					1	4					24
SECURE		1					36	6	2	25	23	9		8	3	3		30	4	10		5	165
NOT YET CONFIRMED/ RECORDED		2	1	1			5		1	1		2		3	1			6	1			1	25
TOTAL NO. OF SPECIES	1	5	6	4	1	1	51	8	3	29	25	14	2	9	6	4	2	51	9	11	1	9	

Definitions of Namibian Provisional Conservation Status categories given in appendix 2

major positive roles in the development of academic reptile research, are now the primary abusers in respect to the exotic reptile pet trade. Namibian Dwarf pythons (*Python anchietae*), dwarf adders (*Bitis* spp.) and tortoises (*Testudinidae*) are all in high demand in Germany and South Africa. Traditional family links often facilitate this trade.

The six species of Namibian tortoises are all edible, and in fact considered a delicacy by nearly all indigenous Namibian people. Historically, the practice of gathering tortoises opportunistically from the veld was probably a sustainable one. However, higher human populations, increased mobility and permanent settlement in previously unsettled areas, facilitated by artificial water points, may be directly threatening tortoise populations today. In addition, the establishment of artificial water points allows the permanent establishment of other species known to eat small tortoises e.g. cattle and baboons.

Historically, the human consumption of tortoises could be controlled by local leaders/land managers, and this may account for regional population trends today. For instance, commercial farmers who had not allowed local labourers and herders to utilise tortoises over the past four generations, still have healthy populations today. Before the Mahango Game Reserve was proclaimed, it was a traditional king's hunting area, with strictly controlled access and utilisation. Today this reserve has a relatively high density of hinged tortoises (*Kinixys spekii*), in a region where they are generally scarce. The gathering and consuming of tortoises by official personnel within parks is also a practice dependent entirely on past and present supervisory staff. The tolerance / intolerance of this practice in the past, has resulted in a simple absence or presence of tortoises in especially the smaller reserves today. Tortoises, especially leopard tortoises (*Geochelone pardalis*), are susceptible to electrified fences, while jackal-proofing restricts the movement of all but small individuals (~40% of the commercial farming area is jackal-proofed.)

Many reptiles are substrate dependent and are therefore vulnerable in today's Namibia where desertification, bush encroachment and deforestation are rapidly spreading. Tree-dependent species, such as the giant tree skink (*Mabuya binotata*), Namibian tree skink (*Mabuya spilogaster*), and some arboreal geckos (*Lygodactylus spp.*), will be directly eliminated from areas as deforestation occurs. Approximately 14 species of Namibian reptiles are water and/or wetland-dependent (Griffin & Channing, 1991). Due to incipient vulnerability of these limited habitats in Namibia (Simmons, Brown & Griffin, 1991) all these species are considered to be threatened. Other than traditional reptiles of conservation concern (e.g. tortoises, pythons, monitor lizards, due to potential commercial over-exploitation) the majority of threatened Namibian species are wetlands-dependent.

Sandy substrates are a major feature of the Namibian landscape and are critical habitat for numerous species, including many endemics. Some of these habitats are reasonably safe from desertification, bush encroachment and deforestation, but are potentially susceptible to e.g. emergency grazing, and large-scale heavy mineral extraction operations.

Rupicolous habitats, on which many species of conservation concern dependent, are fundamentally safe habitats. However, localised and specialised niches are easily destroyed by market and private collectors prying rock crevices apart (e.g. collecting girdle-tailed lizards (*Cordylus spp.*), and scientists collecting study material, crevice-dwelling geckos, scorpions and amblypygids for example). Although this alteration of habitat is probably not significant for wide-spread species, those species whose entire populations are confined to a few mountain tops (e.g. *Cordylus pustulatus* and on mountain hillsides, *Cordylus campbelli*) are extremely vulnerable to this type of local habitat destruction. A significant proportion of scientists/collectors (and all market collectors) are more interested in obtaining quotas, than in local long-term conservation considerations.

Small-scale mining can have detrimental effects on populations of limited-distribution species also. These activities often involve exposed deposits (and habitats), whereas large-scale mining often exploits underground sources, resulting in relatively little disturbance of surface substrate.

The Namibian tortoise fauna of six species (Figure 10), including one endemic species and five of the 11 currently recognised genera, is the second-largest national tortoise fauna in the world (following South Africa with 13 species and 5 genera). Considering that only ~44 species are currently recognized in total, and that all Namibian species are threatened, the *Testudinidae* is the Namibian reptile family of greatest national conservation concern.

Open canal sections of the Eastern National Water Carrier create a 203 km-long pitfall trap for at least 40 species of reptiles in central Namibia (Griffin *et al.* 1989). Annual reptile mortalities are estimated to be a minimum of 50 000. These localised populations may be more resilient than expected though, since the overall rate of mortality has not decreased significantly in the 12 years since the canal was completed and monitoring was initiated.

ALIENS

In the early 1970s, Cape dwarf chameleons (*Brachypodion pumilum*) from the southern Cape coast were introduced to Walvis Bay and Windhoek. Only the coastal introduction subsequently became established. Via the Walvis Bay population, this species has since also been established in Swakopmund, and recently (1991) introduced to Luderitz. This alien is currently confined to domestic gardens in these coastal towns, and is not considered invasive.

The practice of travellers picking up tortoises and translocating them to alien localities is a common phenomenon, today as well as in the past (Greig & Burdett, 1976). Semi-domesticated populations of the angulate tortoise (*Chersina angulata*) thrive in gardens in Swakopmund and Walvis Bay, nearly 500 km north of the closest natural populations. All Southern African tortoise species are involved, and even Chinese three-striped box turtle (*Cuora trifasciata*) were recently found walking around on a farm in the Khomas Hochland. Leopard tortoises are particularly prone to these long distance removals, and this has undoubtedly resulted in genetic pollution of local populations. Leopard tortoises, mostly of unknown origin, breed prodigiously in Windhoek gardens, and the offspring are commonly

transferred to the family farm, thereby contaminating local populations. Even populations in some formal conservation areas can no longer be considered to be genetically characteristic of the area. Parks are often used as dumping grounds for vagrants, orphans and confiscated animals, and over the years many leopard tortoises of spurious provenance have been dumped in (e.g.) the Daan Viljoen Game Reserve and the Namib-Naukluft Park.

PROTECTION STATUS

The Namibian network of formal conservation areas encompasses over 13% of the land area, much of it acquired by default, because at the time of acquisition many of these areas were perceived to be useless for any other immediate use. The areas range in size from 1/4 ha to 50 000km^2 (one of the largest in the world). Most have a recreational component (tourism), but several of the smaller ones especially, are entirely recreation-oriented, and the preservation of biological diversity is not a management issue or goal.

Table 3 summarises the known and expected occurrence of the Namibian reptile fauna within the present formal conservation network. Although the reliability of the occurrence data should be considered quite high, the significance of this data is questionable. The long-term preservation of biodiversity obviously depends on viable populations, and Table 3 makes no inference in this regard. For instance, the common purple-glossed snake (*Amblyodipsas polylepis*) is considered a rare species in Namibia, is known from very few records, with only one specimen known from the Etosha National Park, collected over 20 years ago. This record apparently delineates the extreme western range limit of this species. It is therefore listed as present in a formal conservation area and presumed, perhaps incorrectly, to be 'preserved'. Unfortunately, reliable population data on the greater majority of Namibian reptiles are not available, and are not ever likely to be.

Despite the parsimonious manner in which land was allocated for preservation purposes, the network turned out to be reasonably representative of the diversity of Namibian landscapes (an early goal formulated in the early 1970s was to acquire a minimum of 10% of each of the 15 vegetation types described by Giess (1970)). Approximately 90% of the Namibian reptile fauna is represented, however marginally, within the formal land network, and ~65% of the species occur in three or more reserves, and ~23% in 10 or more reserves.

Areas neglected in the current formal conservation network are the pro-Namib and escarpment extending from the Erongo mountains to the Kunene river. A major proportion of endemics occur in this region (Figures 6, 7 and 8), and although many species occur marginally in adjacent conservation areas (e.g. Skeleton Coast and Etosha National Park), these endemics require additional protection in more centralised core regions.

Although nearly 40 km of the Kunene River flows through the Skeleton Coast Park and is therefore protected, little of the typical riparian vegetation community, as habitat, is included in the lower section of the river.

TABLE 3

PROTECTION STATUS OF INDIGENOUS NAMIBIAN REPTILES

NUMBER OF SPECIES PER FAMILY OCCURING IN FORMAL CONSERVATION AREAS[1]
(INCLUDING THOSE SPECIES EXPECTED TO OCCUR)

CONSERVATION AREA	REPTILE FAMILIES																			
	CROCODYLIDAE	PELOMEDUSIDAE	TESTUDINIDAE	CHELONIIDAE	DERMOCHYLIDAE	TRIONYCHIDAE	GEKKONIDAE	AGAMIDAE	CHAMAELEONIDAE	SCINCIDAE	LACERTIDAE	CORDYLIDAE	VARANIDAE	AMPHISBAENIDAE	LEPTOTYPHLOPIDAE	TYPHLOPIDAE	BOIDAE	COLUBRIDAE	ATRACTASPIDAE	ELAPIDAE	HYDROPHIIDAE	VIPERIDAE	TOTAL
MUDUMU & MAMILI	1	4	3	0	0	0	6	2	1	5	3	2	2	6	2	1	1	25	7	7	0	3	81
WEST CAPRIVI	1	4	3	0	0	0	6	2	1	6	4	2	2	5	1	1	1	24	5	6	0	2	77
MAHANGO	1	3	3	0	0	0	7	3	1	6	7	2	2	5	1	1	1	23	3	5	0	2	72
KAUDOM	0	1	2	0	0	0	16	2	1	6	9	4	1	4	0	3	1	16	4	5	0	3	66
ETOSHA	1	1	2	0	0	1	16	5	1	6	8	4	1	6	3	3	2	26	5	8	1	3	109
SKELETON COAST[2]	0	0	2	0	1	0	21	2	1	8	10	4	1	4	2	3	2	17	6	1	0	2	77
WATERBERG PLATEAU	+	1	2	4	0	0	7	5	1	10	11	3	1	3	2	3	2	20	1	7	0	2	83
DAAN VILJOEN	0	1	2	0	0	0	10	2	1	10	10	3	1	2	2	3	2	18	0	7	0	2	79
VON BACH DAM	0	1	4	4	0	0	22	1	1	13	13	2	0	3	1	2	1	17	0	4	1	4	76
NAMIB NAUKLUFT	0	1	0	0	0	0	13	4	1	7	8	3	1	2	0	2	1	7	0	2	1	3	100
WALVIS BAY	+	0	2	4	0	0	12	2	1	8	9	2	0	3	1	3	0	13	0	5	0	2	50
HARDAP DAM	0	1	3	0	0	0	13	4	1	10	6	3	1	1	0	1	0	13	0	3	0	4	62
NAUTE DAM	+	1	0	4	0	0	7	2	1	5	4	2	0	2	1	2	0	7	0	1	0	2	66
DIAMOND COAST	0	0	4	0	0	0	16	4	2	10	6	3	1	4	2	4	0	16	0	3	0	4	38
HUNSBERG / AI-AIS	0	1	6	4	1	1	51	8	3	29	25	14	2	9	5	4	2	51	9	11	1	9	74
TOTAL SPECIES IN NAMIBIA	1	5	6	4	1	1	41	8	3	24	22	8	2	9	5	4	2	45	7	11	1	8	217
TOTAL SPECIES IN PARKS	1	4	6	4	1	1	41	8	3	24	22	8	2	9	5	4	2	45	7	11	1	8	217

1) Not including those areas of less than 1000 ha.
2) Including Cape Cross Seal Reserve and West Coast Recreation Area

The north-eastern region is well endowed with approximately 1 100 km of perennial rivers, including adjacent riparian habitats. However, these habitats tend to be extremely vulnerable, due in part to their lack of depth, and large tracts have already been degraded. Of the 470 km of the Kavango river bordering or running through Namibia, for instance, less than 30 km is not severely degraded by human activities. Fragments of only ~100 km. (11%) are currently incorporated within the national protected area network in this region, while the Zambezi River, of which over 150 km borders Namibia (including the flood plain, which is a major feature in the East Caprivi) is not represented at all. Approximately 80 km (~13% of the entire national frontage) of the Orange River is proclaimed as part of the Hunsberg-Ai-Ais complex. This section is not well protected, however, due to numerous human activities in the area.

Nearly all groups of Namibian reptiles, as well as most species of conservation concern are represented, at least marginally, within the current protected area network. Exceptions are the cordylids where at least three endemic species occur on private lands only (i.e. *Cordylus pustulatus*, *C. campbelli*, and *C. namaquensis*), and some geckos endemic to the Kunene and Erongo regions. Specifically, proclaiming sections of the Kaokoveld and the Sperrgebiet, as has been proposed recently (AGM, 1996) will assure the viability of some habitats/landscapes and associated species, that are currently protected only marginally.

The national protection area network is not inviolate, as boundaries can be changed at will by Parliament. As many of the present preservation areas are bordering commercial and/or communal lands, pressure is high to open these areas for regular emergency grazing, or even re-allocation due to post-independence land reform. This possibility, as well as the need to extend the present network to include specialised local habitats and specific species, requires co-operation and partnership between the formal and informal sectors. Recent initiatives along these lines, proclaimed private game reserves, commercial and communal conservancies, and controlled access mining concessions (e.g. the Sperrgebiet) are examples of pragmatic ways to ensure the preservation of the greatest possible array of Namibia's rich reptile fauna. The down-side of commercialising conservation/preservation, however, is that most private initiatives cater to the expectations of eco-tourists, and manage the land accordingly. This can lead to a degraded situation in regards to the overall spectrum of local biodiversity.

The Nature Conservation Ordinance (No. 4 of 1975) lists (and therefore implies regulation and control of) the Nile crocodile, the two varanids, two pythons and all testudinidae. These are 'Protected Game' in Namibia. No reptiles are listed as 'Specially Protected', 'Huntable Game', or 'Problem Animals'. All other reptiles are defined as 'Wild Animals', which confers a greatly reduced protection status on them. Marine turtles were not included in the Nature Conservation Ordinance, but are now fully protected in the new Sea Fisheries Regulations (No.1 of 1993). By definition, the disjunct population of African soft-shelled turtles at the Kunene River mouth are also fully protected by these regulations.

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APPENDIX 1

PHYLOGENY AND DIVERSITY OF INDIGENOUS NAMIBIAN REPTILES

The figures in brackets after higher taxa refer to the number of those taxa occurring (or expected to occur) in Namibia / total number found worldwide. Figures in brackets after listed genera refer to the number of species occurring or expected to occur in Namibia / total number of species currently recognized within that genus. No attempt has been made to list taxa in phylogenetic order.

CLASS REPTILIA

ORDER (3/4)

CROCODILIA

FAMILY (1/3)

CROCODYLIDAE

GENERA (1/3)

CROCODYLUS (1/12)

CHELONII

FAMILY (5/12)

PELOMEDUSIDAE

GENERA (2/2)

PELUSIOS (4/14)

PELOMEDUSA (1/1)

TESTUDINIDAE
GENERA (5/10-15)
CHERSINA (1/1)
GEOCHELONE (1/15)
HOMOPUS (1/5)
KINIXYS (2/5?)
PSAMMOBATES (2/3)

CHELONIIDAE
GENERA (4/4)
CHELONIA (1/3)
CARETTA (1/1)
ERETOCHELYS (1/1)
LEPIDOCHELYS (1/2)

DERMOCHELYIDAE
GENERA (1/1)
DERMOCHELYS (1/1)

TRIONYCHIDAE
GENERA (1/3)
TRIONYX (1/15)

SQUAMATA

SAURIA (SUBORDER)
FAMILY (7/16+)
GEKKONIDAE
GENERA (12/63)
AFROEDURA (3/12+)
CHONDRODACTYLUS (1/1)
COLOPUS (1/1)
PALMATOGECKO (2/2)
PHELSUMA (1/25)
PTENOPUS (3/3)
RHOPTROPUS (5/6)
HEMIDACTYLUS (2/70+)
LYGODACTYLUS (5/50+)
NARUDASIA (1/1)
PACHYDACTYLUS (20/30+)
PHYLLODACTYLUS (2/62+)

AGAMIDAE
GENERA (2/35+)
AGAMA (7/60+)
ACANTHOCEROS (1/1)

CHAMAELEONIDAE
GENERA (2/4)
BRADIYPODION (1/20+)
CHAMAELEO (2/2)

SCINCIDAE
GENERA (8/75)
ACONTIAS (2/7)
TYPHLOSAURUS (4/9)
SEPSINA (2/5)
SCELOTES (1/15)
TYPHLACONTIAS (5/6)
LYGOSOMA (1/35)
MABUYA (13/85)
PANASPIS (1/33)

LACERTIDAE
GENERA (5/25)
MERTENSIELLES (8/8)
ICHNOTROPUS (3/7)
PEDIOPLANIS (10/10)
HELIOBOLIS (1/4)
NUCRAS (3/7)

CORDYLIDAE
GENERA (5/10)
ANGOLOSAURUS (1/1)
CORDYLOSAURUS (1/1)
CORDYLUS (6/20)
GERRHOSAURUS (5/6)
PLATYSAURUS (1/10)

VARANIDAE
GENERA (1/1)
VARANUS (2/30)

AMPHISBAENIA (SUBORDER)
FAMILY (1/4)
AMPHISBAENIDAE
GENERA (3/15)
DALOPHIA (3/7)
MONOPELTIS (6/16)
ZYGASPIS (2/7)

SERPENTES (SUBORDER)
FAMILY (7/12)
LEPTOTYPHLOPIDAE
GENERA (1/2)
LEPTOTYPHLOPS (6/77)

TYPHLOPIDAE
GENERA (1/2)
RHINOTYPHLOPS (4/130)

BOIDAE
GENERA (1/20)
PYTHON (2/10±)

COLUBRIDAE
GENERA (22/292)
LAMPROPHIS (3/13)
LYCOPHIDION (3/14)
MEHEYA (3/10)
PSEUDASPIS (1/1)
PYTHONODIIPSAS (1/1)
LIMNOPHIS (1/2)
NATRICITERES (1/3)
HEMIRHAGERRHIS (2/3)
PSAMMOPHYLAX (3/3)
RHAMPHIOPHIS (1/4)
DIPSINA (1/1)
DROMOPHIS (1/2)
COLUBER (1/35)
PSAMMOPHIS (9/20+)
PROSYMNA (5/12)
MEIZODON (1/3)
PHILTHAMNUS (4/18)

CROTAPHOPELTIS (2/6)
TELESCOPUS (3/8)
DISPHOLIDUS (1/1)
THELOTORNIS (1/2)
DASYPELTIS (1/6)

ATRACTASPIDIDAE
GENERA (4/6)
APARALLACTUS (2/11)
AMBLYODIPSAS (2/9)
XENOCALAMUS (2/5)
ATRACTASPIS (3/15)

ELAPIDAE
GENERA (4/61)
ELAPSOIDEA (2/7)
ASPIDELAPS (2/2)
NAJA (5/16)
DENDROASPIS (1/4)

HYDROPHIIDAE
GENERA (1/14)
PELAMIS (1/1)

VIPERIDAE
GENERA (2/17)
CAUSUS (1/6)
BITIS (7/14)

APPENDIX 2

The following definitions apply to the Namibian Conservation Status categories used in this report:

EXTINCT: Taxa definitely not located in the wild in Namibia during the past 50 years, and supported by reasonable evidence that the species is no longer locally extant. Reintroductions from non-Namibian populations do not negate this status.

ENDANGERED: Taxa in danger of extinction and whose survival is unlikely if the causal factors continue operating. Included are taxa whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that they are deemed to be in immediate danger of extinction.

VULNERABLE: Taxa believed likely to move into the ENDANGERED category in the future if present causal factors continue operating. Included are taxa of which all or most of the populations are decreasing because of over-exploitation, intensive destruction of habitat or other environmental disturbance: Taxa with populations which have been seriously depleted and those whose ultimate security is not assured, and taxa with populations that are still abundant but are under threat throughout their range.

RARE: Taxa with small populations which are not (thought to be) presently ENDANGERED or VULNERABLE, but which are potentially at risk. These species can be thinly scattered over an extensive range in Namibia. These may be species which are seldom recorded but may be more common than supposed, although there is some indication that their numbers are low. Also includes taxa which have a restricted geographical range in Namibia, have an intermediate endemicity (26% - 74%), and may be locally abundant, but since the taxon's overall range is very limited, it may not be SECURE.

INDETERMINATE: Taxa that are known to be, ENDANGERED, VULNERABLE, or RARE but for which insufficient information is currently available to assign them to the appropriate category. The predicted category may be given in brackets, e.g. (VULNERABLE?).

INSUFFICIENTLY KNOWN: Taxa that are suspected but not definitely known to belong to any of the above categories, because of insufficient information. The predicted category may be given in brackets e.g. (RARE?).

SECURE: No special threat status. Taxa with no known local conservation problems, and no reason to believe that the conservation-status of the taxa will change in the future. A decline in status would, however indicate a deterioration of the Namibian environment.

ENDEMIC: Restricted to, or found almost exclusively in Namibia. This category simply states the non-negotiable national obligation to conserve the taxon. No conservation "problems" are implied. Endemic in this context includes all taxa with 75% or more of the entire taxon's population residing in Namibia. In the case of most smaller terrestrial vertebrates, estimates are based on proportions of geographic range/required habitat, and this is assumed to roughly correspond to proportions of the taxon's entire population. The estimated rate of endemicity is give in brackets i.e. between 75% - 100%.

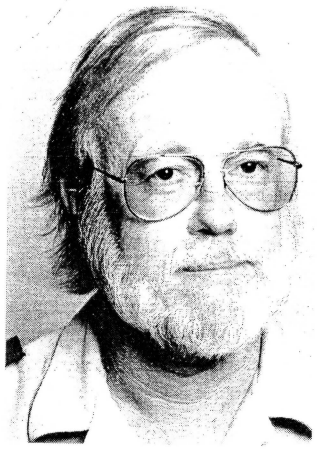
PERIPHERAL: Taxa with a limited proportion of their distribution in Namibia (25% or less) and whose main distribution falls outside the political boundaries of the country. In addition, the Namibian population could, or is known to be threatened and the status should be monitored. Namibia is not the sole guardian and the local loss would not necessarily result in the extinction of the taxa, but would reflect deterioration of the Namibian environment, and could effect the taxon's overall conservation status. Includes taxa with very limited overall distributions (and are therefore vulnerable, because of

localized catastrophic events), taxa with very specific (and vulnerable) habitat requirements, and taxa of international concern for any reason (eg. cetaceans & marine turtles). Often used as an additional information suffix to a threatened category. Refers to established or transitory populations, as opposed to VAGRANTS, which refers to odd individuals of mobile species, for which Namibia would have a minimal amount of conservation responsibility.

STATUS PROVISIONAL (SP): Qualifier suffix attached to conservation-status categories, indicating inadequate information on the taxon's taxonomic and/or biogeographical status. Further information could (in many cases would) change the species? conservation-status ranking. The factor in question is given in brackets (e.g. taxonomy of subspecies).

NOT YET RECORDED: Taxa not yet recorded from Namibia, but because of known habitat / distribution and environmental factors, can reasonable be expected to occur. No conservation-status ranking is implied in this definition. However, most taxa would probably be initially classified as "PERIPHERAL" or "RARE". The expected conservation status is sometimes appended to this category. This category implies the qualifier suffix SP (STATUS PROVISIONAL).

NOT YET CONFIRMED TO OCCUR: Taxa which have been previously recorded, but not confirmed. There may be some question as to the accuracy of the original record.



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