Overview of the trade of reptile taxa consumed for therapeutic purposes across Africa

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Abstract

Although zootherapy is complementary to the body of knowledge on plant-based medicine, few African studies have attempted to identify and record the trade of therapeutic reptiles. This report analyses and provides an overview of the continent-wide (African) trade of reptiles for therapeutic purposes. The results show that at least 101 reptile species are used for therapeutic purposes in traditional medicine markets across Africa. Among these 101 therapeutic species, 40 are listed on the IUCN Red List and 44 are included in some of the CITES Appendices. Additionally from a species rarity perspective, the most frequently recorded species tended to be very common where they occur, and the least frequently recorded species tended to be the rarest. When enumerating in terms of the African Union regions, West Africa (especially Togo) and southern Africa (especially South Africa) yields the highest number of species recorded. The most sought therapeutic species appear to be *Crocodylus niloticus*, which was recorded in 17 countries, followed by *Varanus niloticus* (n=9 countries) and *Python sebae* (n=8 countries). With records in 22 countries each, pythons and crocodiles (morphospecies) appear to be the most sought for therapeutic purposes. In light of the deficit in information on trade and/or utilisation, the results demonstrate the urgent need to understand and identify the species traded in the context of reptile conservation.

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Glossary

AU – the African Union
CITES – the Convention on International Trade in Endangered Species
IUCN - International Union for Conservation of Nature

Country ISO codes (listed alphabetically). No information was obtained for countries in the grey cells (see map layout in Fig. 2)

ISO CODE – Country name	ISO CODE – Country name
AO – Angola	**MG** – Madagascar
BF – Burkina Faso	**ML** – Mali
BI – Burundi	**MR** – Mauritania
BJ – Benin	**MU** – Mauritius
BW – Botswana	**MW** – Malawi
CD – Democratic Republic of Congo	**MZ** – Mozambique
CF – Central African Republic	**NE** – Niger
CG – Congo	**NG** – Ghana
CI – Cote d'Ivoire	**NG** – Nigeria
CM – Cameroon	**RW** – Rwanda
CM – Cameroon	**SD** – Sudan
CV – Cabo Verde Republic	**SL** – Sierra Leone
DJ – Djibouti	**SN** – Senegal
DZ – Algeria	**SO** – Somalia
EH – West Sahara	**SS** – South Sudan
EG – Egypt	**ST** – São Tomé and Príncipe
ER – Eritrea	**SZ** –Swaziland
ET – Ethiopia	**TD** – Chad
GA – Gabon	**TN** –Tunisia
GM – Gambia	**TZ** – Tanzania
GN – Guinea	**UG** – Uganda
GQ – Equatorial Guinea	**ZA** – South Africa
GW – Guinea-Bissau	**ZM** – Zambia
KE – Kenya	**ZW** – Zimbabwe
KM – Comoros	
LB – Liberia	
LS – Lesotho	
LY – Libya	
MA – Morocco	

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Chapter 1

1. Introduction

The uses of animals for therapeutic purposes ('zootherapy' [Costa-Neto, 1999; Lev, 2003]) have been documented – usually under the umbrella term 'traditional medicine', and includes complex uses that involves rituals (e.g. appeasing traditional gods and conjuring evil spirits or protection from witchcraft) (Adeola, 1992). Indigenous societies believe in 'black' magic, superstitious notions and primitive customs such as eating the raw fresh heart of a lion or applying python fat as a lotion to imbue its strength. Humans have always attempted to capture the strength and magical powers of animals (Alves and Souto, 2015), to eradicate imbalances caused by evil-minded fellows and to aid in appeasing ancestral gods. All these uses are therapeutic.

The exploitation of animals for therapeutic purpose is a traditional norm and is fuelled by factors such as the expanding human population and increasing unemployment. Therefore, the trade in zootherapeutic wildlife by local populations has become an attractive economic diversification response in developing countries. Despite ethnomedicinal plants being most widely used as the main source of remedies or base products in therapies, there has been a growth in the trade and use of animals (Alves *et al*. 2013). The number of species traded in traditional medicine markets correlates with the number of species traded (Anyinam, 1995), as traditional medicine markets has grown, so has the targeted therapeutic species (Williams *et al*., 2014). The trade in therapeutic animals in traditional medicine markets calls for an increased understanding of the trade and the identification of species traded, especially species of conservation concern (Alves and Pereira-Filho, 2007; Alves *et al*., 2009)

Zootherapy is an old practice and is as common as the use of plant-based therapies (Alves and Rosa, 2005). Unfortunately, it has been largely ignored in ethnozoological literature. In this context, the study reviews the literature on the trade of reptiles in African traditional markets to contribute to the knowledge gap.

1.1. Reptiles in zootherapy

Zootherapy has deep historical origins. Unfortunately, written historical sources pertaining to the trade or use of reptiles to treat ailments are not of great antiquity. However, Lev (2006)

highlighted that the historical uses of animals (including reptiles), in Egyptian papyruses mention the medicinal uses of substances derived from lizard blood, and that ancient Mesopotamian archives contain descriptions of turtle shells. Moreover, excerpts from historical plays, e.g. Shakespeare's Romeo and Juliet acts highlighted the trade of crocodiles and tortoises, viz. "*...and in his shop a tortoise hung, An alligator stuff'd, and other skins of ill-shap'd fishes, and about the shelves*…" (Longfellow, 2011). Unfortunately in Africa, apart from some anecdotal information in some general zoological literature and few studies on the topic (e.g. Simelane and Kerley, 1998; Segniagbeto *et al.*, 2013; Williams *et al.*, 2014), there is a general lack of information on the use of reptiles.

Most reptile uses for traditional medicine are driven by the 'doctrine of signatures', a theory by Boehme (1651) which states that natural objects resembling certain body parts could cure illnesses that would arise on those body parts. That is, the morphology of plants and animals, and the way they taste or their traits suggest their medicinal application Lev (2002a; 2002b). For instance, the power of a python signifies that its by-product is alleged to be powerful enough to heal just about anything. Some of the notable examples of recorded reptile by-products in traditional medicine markets include snake and crocodile skins, and turtle shells that could be bushmeat leftovers (Klemens and Thorbjarnarson, 1995; Barzyk, 1999); and carcasses of chameleons and some agamid lizards that could be dead pre-exports of the pet trade (Franke and Telecky, 2001). These forms of exploitations are intertwined to an extent (Klemens and Thorbjarnarson; 1995; Alves *et al.*, 2009) and are similar in terms of their logistics by involving the exploiters and end-users.

1.2. Implications for conservation

Factors contributing to the observed declines in reptile populations include habitat modification (land population and fragmentation), climate change, competition from invasive species and ultraviolet radiation (Schlaepteer *et al*., 2005). Trade in therapeutic reptiles constitutes an additional form of pressure to their decline (Gibbons *et al.*, 2000; Fitzgerald *et al*., 2004) has important conservation consequences, especially for heavily-harvested species (Conway, 1998). Some studies (e.g. Klemens and Thorbjanarson, 1995) in Asia pointed out that the Threatened tortoises and turtles in Asia are a result of over collection for food and traditional medicine. In Nigeria, Ita (1994) indicated that the demand for crocodile skins, meat and other body parts has led to the declines in their populations, as in Mexico for population of

rattlesnakes (Fitzgerald *et al*. 2004). Regardless of the conservation legislation and regulations per country, exploitation of commercially available species comprise an 'invisible' commodity and their harvest often continues unrestrained. The management of commodified species is a challenge in conservation due to a lack of clear ownership. This results in a situation where a shared and unmonitored resource is used in an unmanaged way to its unintended ruin or total consumption by a number of participants – a 'tragedy of the commons' (Hardin, 1968).

Assessing the impact of trade on commodified species is very difficult because the trade is secretive especially when the trade is illegal (Chaúque, 2010; Williams *et al.*, 2016; Alves and Rosa, 2010). The clandestine trade operations indicate that the traders are largely aware of the conservation legislation and policy put out for Threatened species. In South Africa, access into traditional medicine markets (e.g. Warwick *muthi* market – traditional medicine in Durban; Faraday traditional medicine market – Johannesburg) is often prohibited by market leaders despite institutions' ethics committee protocol clearance (pers. obs., June 2014). This is a similar situation in Mai Mai traditional medicine market (Johannesburg) [Mbongwa, pers. comm., March 2017]. This is largely due to conservation policy, regulations set out in the country leading to traditional medicine market raids, and arrests of unlicensed traders of Threatened species. Often, because of the illegality of the trade and commodified animal parts, traders often require payment to be cooperative (pers. obs., February 2016). With these 'unethical' situations, market surveys are often carried out undercover using mental notes leading to certain species being overlooked.

Conservationist call for the understanding of the sociocultural reasons for trading targeted species and the trade logistics involved of to establish management plans to ameliorate their overexploitation. However, this is often difficult given the hostility of the traditional medicine markets and that most traders lack the indigenous knowledge of the species they trade (Williams *et al*., 2016) because they focus primarily on the monetary value of species they trade for their economic wellbeing. The sociocultural understanding of species traded in the indigenous communities can offer valuable insights to implementing their sustainable uses. For instance, some of the indigenous knowledge includes taboos, which prohibits overutilization of natural resources. For example, the Shona saying "*ukauraya shato, mvura haizonayi*" (Chemhuru and Masaka, 2010) meaning "*if you kill a python rain will not fall*" is an African traditional taboo which played a conservation and historical role in maintaining the population of pythons which are now among the most sought after species for zootherapy.

1.3. Report overview and structure

This report gives an overview of therapeutic reptiles in Africa on the basis of the already published data, and is inspired by the study of therapeutic African avifauna in Williams *et al*., (2014). The study objectives are covered over four chapters:

Chapter 1 provides a general introduction on zootherapy and highlight the gaps on the subject and the importance of research focusing on traded therapeutic reptiles species.

Chapter 2 outlines the general materials and methods used in this report.

Chapter 3 describes the taxonomic richness of therapeutic reptiles recorded for therapeutic purposes, and enumerates them per country and region. Additionally, a percentage similarity of species and morphospecies [group of taxa separated based on morphological characters that are easily observable (Derraik *et al*., 2002) and are largely recognized by indigenous people and modern taxonomists as the same taxon, e.g. pythons or tortoises] between the countries is assessed. This chapter includes a brief introduction, detailed methods specific to the chapter, results, and discussions.

Chapter 4 is conservation-based and gives an overview of the patterns of the rarity of therapeutic species recorded. This chapter follows a scientific method and includes a brief introduction, detailed methods specific to the chapter, results, and discussions.

Chapter 2

2. Materials and methods

2.1. Data source

To give an overview of the continent-wide trade and use of reptiles, all available references, reports or anecdotal information about the subject were reviewed. These were: Loeb *et al*. (1956); Taylor (1962); Bryant and Litt (1966); Ntiamoa-Baidu (1987); Nevadomsky (1988); Cunningham and Zondi (1991); Adeola (1992); Taylor and Fox, (1992); Fratkin, (1996); Simelane (1996); Marshall (1998) [including data from Gelfand *et al*. (1985); Behra (1992); Clark *et al*. (1993); Clark and Khatib (1993); Rakotonirima and Cooke (1994); Guissamulo (1996); Simuyi *et al*. (1996); Maliwichi (1996); Mukamuri (1996); Muswema and Mpengula (1996); Van Damme (1996); Mbewe (1996); Desalegn *et al*. (1996); Amai (1996), Gubelman and Kavu (1996); Khatano (1997) and MAPRI (1997)]; Morris (1998); Simelane and Kerley (1998); Sodeinde an Soewu (1999); Hamissou (2000); Ngwenya (2001); Haule (2002); Edwards (2003); Noumi (2004); Dedeke *et al*. (2005); Amir (2006); Ba *et al*. (2006); Highfiled and Bailey (2007); McMillen (2008); Soewu (2008); Olupot *et al*. (2009); Chaúque (2010); Whiting *et al*. (2011) [including their unpublished data]; Ondutan *et al*. (2012); Segniagbeto *et al*. (2013); Bergin and Nijman (2017); Yohannes and Chane (2014); Bobo *et al*. (2015); Vats and Thomas (2015) and Williams *et al*. (2016).

With the deficit in medicinal reptile studies and the clandestine trade operations that makes market surveys difficult (Alves and Rosa, 2010; Chaúque, 2010; Williams *et al*., 2016), internet images of reptiles traded in traditional medicine markets in Africa supplemented the inventory. Regrettably, the inferiority of some images and the decaying status of photographed carcasses and skins affected species identification negatively. With these caveats in mind, the reptile inventory is considered incomplete; therefore, the results herein must be viewed cautiously.

Conservation assessment data extracted from several online databases (see below) augmented the results and discussion of this study:

- The Reptile database (http://www.reptile-database.org/): This reference provided the taxonomy applied (Uetz and Hošek, 2017). However, for species occurring in South Africa and Swaziland, the regional taxonomic arrangement in the Atlas and Red List of

the Reptiles of South Africa, Lesotho and Swaziland (Bates *et al*. 2014) was followed. The inventory taxonomy is correct to June 2017.

- CITES Trade database (http://www.cites.org/): Search entry for all reptile taxa recorded in all Appendices (I–III). The CITES Appendices included amendments of the Conference of Parties (CoP) 17 held in South Africa in 2016.
- IUCN Red List (http://www.iucnredlist.org): All reptile species listed in any of the threat categories. The IUCN Red List assessments provide the species status based on expert knowledge. However, some assessments are in need of an update. Therefore, for species endemic to South Africa, Lesotho and Swaziland, the regional Southern African Reptiles and Amphibians (SARCA) statuses in Bates *et al*., 2014 were followed

2.2. Data fusion

To minimize questionable data, the study carefully tallied the total number of species traded and classified (nomenclature) the reptile taxa as follows:

- Reptiles that were not recognised beyond genus and those recognised up to family were excluded from the analysis. Such taxa were included in the analysis when their data entry resulted in an exclusive genera per country and region. For instance, a *Varanus sp* in country A would be analysed when no other species of the same genus was recorded in country A.
- Exotic taxa (i.e. not African) were classified as 'unidentified' and excluded from the analysis. For instance, Segniagbeto *et al*. (2013) identified an iguanid lizard in the market of Lomé in Togo. Although the genus *Iguana* lacks a range in Africa, its importation for pet trade and occurrence in the traditional medicine markets as a dead imports is a possibility. Therefore, the iguanid lizard was classified as an ‘unidentified lizard’ in this report’s inventory.
- The ranges of species that have recently undergone taxonomic revision resulting in the splitting of their taxa were cross-checked and validated. For example, *Python sebae* occurs in the northernmost parts of Africa (Northern African python) and *Python natalensis* (southern African python) southernmost parts. Therefore, *Python* species were renamed either *P. sebae* or *P. natalensis* based on the countries they were recorded in. Although the smuggling of these species into foreign countries is plausible, their identities in the traditional medicine markets are largely erroneous.

- Species recorded as being used for therapeutic purposes but not recorded for trade in traditional medicine markets (non-market records) were included in the analysis. This is because used taxa are likely to be traded for therapeutic purposes. Moreover, consideration of the use data compensates for possible market survey overlooks.

2.3. Species richness and patterns of rarity and commonness

Reptiles identified down to species were categorized into rarity categories (ranging from A - H) based on three factors (i.e. population size; geographic range; and habitat preference) following a touchstone model for current discussions of commonness and rarity in Rabinowitz (1981); and Rabinowitz *et al*. (1986) [Table 1].

Table 1. The Rabinowitz's common and seven forms of rarity. The model was adapted by Yu and Dobson (2000) and includes the incorporated rarity ranks (numbers in brackets).

Geographic Range		**Large**		**Small**	
Local population size		**Large, dominant somewhere**	**Small, non-dominant**	**Large, dominant somewhere**	**Small, non-dominant**
Habitat specificity	**Wide**	(**A**) Locally abundant in several habitats over a large geographic area (**4**)	(**C**) Constantly sparse in several habitats over a large geographic area (**3**)	(**E**) Locally abundant in several habitats over a small geographic area (**3**)	(**G**) Constantly sparse in several habitats over a small geographic area (**2**)
	Narrow	(**B**) Locally abundant in a specific habitat over a large geographic area (**3**)	(**D**) Constantly sparse in a specific habitat over a large geographic area (**2**)	(**F**) Locally abundant in a specific habitat over a small geographic area (**2**)	(**H**) Constantly sparse in a specific habitat over a small geographic area (**1**)

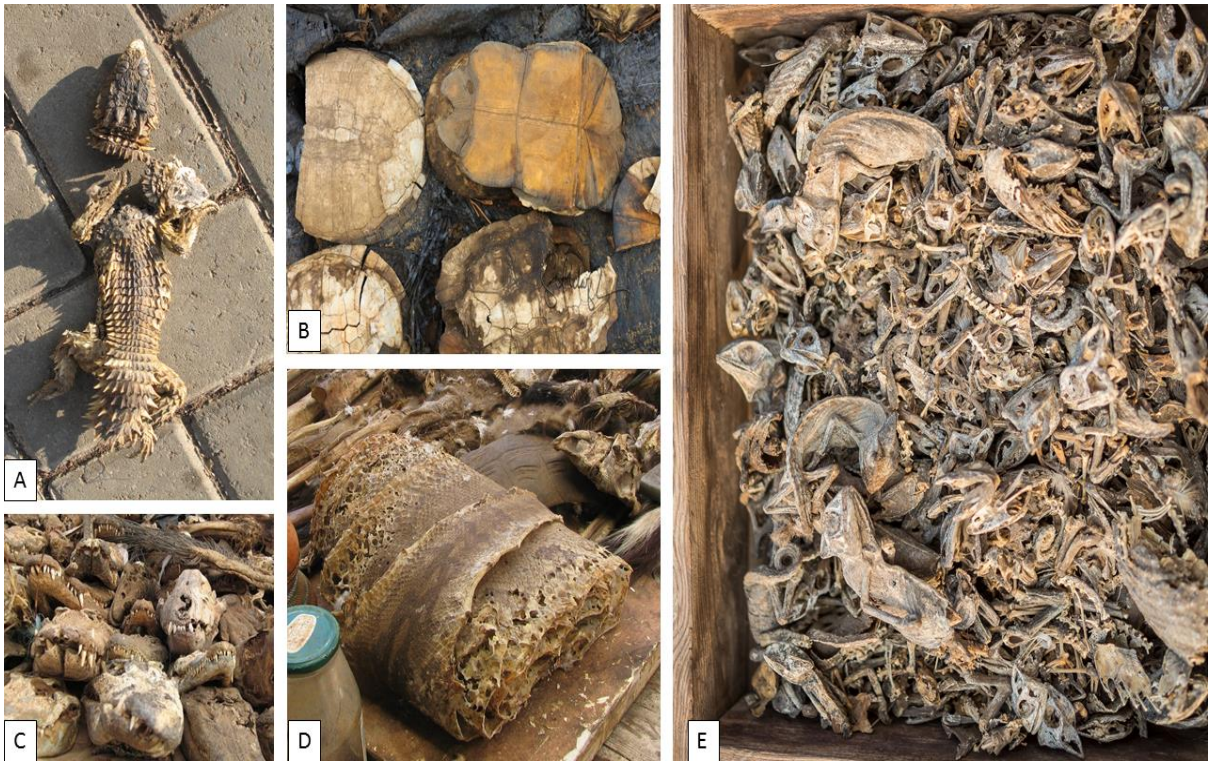

Figure 1. Reptile species in the African traditional medicine trade. **A**. *Smaug giganteus* (sungazer) placed to dry in Faraday traditional medicine market, South Africa. **B**. Tortoise shells sold in Akodessewa market in Lomé, Togo. **C**. Different heads of crocodile species on display in Akodessewa market. **D**. A rolled *Python natalensis* (southern African python) skin on display in Faraday traditional medicine market. **E**. Chameleon skeletons in a crate in Akodessewa market in Lomé, Togo [Photos: V.L Williams (Faraday market), S. Lazar (Akodessewa market)].

Yu and Dobson (2000) adapted Rabinowitz's rarity model by including the rarity ranks from 1 to 4 (rarest to least rare) where rarity category H (ranked 1) contains species rare in all three factors, and indicated the highest degree of rarity (see Table 1). Species above and below the median for all three factors were considered to be comparatively common and rare, respectively. The mean rarity rank of morphospecies groups [group of taxa separated based of morphological characters that are easily observable (Derraik *et al.*, 2002) and are largely recognized by indigenous people and modern taxonomists as the same taxon, e.g. pythons or tortoises] and species within the countries and regions were determined. Morphospecies with the mean rarity rank values closer to 1 were rarer, and those with the mean rarity rank values closer to 4 were common. Rare morphospecies had the mean value below the mean of the rarity ranks (e.g. the mean value of 1, 2, 3 and 4=2.5). Therefore, common morphospecies had the mean value at or above the mean of the rarity ranks – any value above 2.5.

Chapter 3

3. Taxonomic richness of therapeutic reptiles

3.1. Introduction

There are 1654 species of reptiles in Africa (excluding Madagascar) (Uetz *et al*., 2015). However, the extent of their trade for therapeutic purposes is relatively unknown. In biodiversity conservation, key questions are how species richness is distributed in space and where it varies and changes the most (Maestri and Patterson, 2016). These are perhaps easy questions to ask but remain largely unanswered in conservation biology. The answers to such questions are important to researchers and conservationists alike but can be misleadingly hard to obtain (Park and Tonkyn, 2015). Species richness is simply defined as the number of species present at a particular site. Species richness can be used as a tool for conservation planning to monitor changes in the ecosystem (Pereira *et al*., 2013). Therefore, knowing the species available in a particular location is necessary to orient decision-making process and choices (Preatoni *et al*., 2014).

Measuring compositional similarity or difference between two areas is a key step for knowledge discovery tasks. More than 75 measures of compositional similarity can be found in the literature (Choi *et al*., 2010), and are among the most common measures for comparing two or multiple sites (Diserud and Ødegaard, 2007). Both Jaccard (see Jaccard, 1912) and Sørensen (see Dice, 1945 or Sørensen, 1948) indices are commonly applied for relative compositional similarity analysis (Legendre and Legendre, 1983). Originally, both indices were developed to compare similarities between two assemblages where the Jaccard index calculates similarity based on total number of species in the combined locations while Sørensen index compares similarity based on the mean number in a single location (Magurran and McGill, 2011). According to Wolda (1981), the Sørensen index is a true overlap measure by giving the proportion of an assemblage's species list that overlaps with the species list of the next assemblage. This is the harmonic mean of the proportion of the shared species in the initial location together with the proportion of shared species in the next location (Magurran and McGill, 2011). Therefore, Sørensen index was used in this report to compare relative similarity of traded therapeutic species across Africa.

3.2. Materials and methods

3.2.1. Similarity analysis

Similarity indices measures variations in species composition and species shared between two sites being compared (Novotny and Weiblen, 2005). The Sørenson similarity index (Magurran, 2004) is a multiple-site similarity measure based on presence-absence data (derived from this report's inventory); the index was used to measure reptile species similarity between two different countries. In this report, the Sørenson similarity index (unlike Jaccard's) was used for similarity analysis to ignore joint absences and to take into account the importance of the species in common between two sites. The percentage similarity of species and morphospecies traded and used in various African countries were calculated using the EstimateS software (Version 9.1.0). Information on the number of species shared across two sites and observed in one site is preserved by the software; therefore, the average similarity between sites tells us the extent of change in shared species between pairs. The similarity measure of the total 135 reptiles recorded was determined, however:

- For regional enumeration, a particular species was enumerated once (e.g. a number of *Python sebae* records in numerous West African countries made a single species count for the region).
- Reptiles that were not recognized beyond genus were only enumerated as a species only when they resulted in an exclusive genus for the region.

3.2.2. Cluster analysis

One function of clustering is to organize data objectively into homogenous groups to minimize the inside-group-object similarity and maximize the between-group-object dissimilarity (Liao 2005). The focus this report is to summarize the similarities and/or dissimilarities of species and morphospecies traded in various African countries using a dendrogram (highly interpretable complete description of the hierarchical clustering in a graphical format) produced using the agglomerative Ward's clustering method using PAleontological STatistics (PAST) software (Version 3.15) [Hammer *et al.*, 2001]. The similarity association matrix upon which clustering are based on was computed using the Euclidean distance index for presence-absence data and the Ward's algorithm. The Euclidean distance is a straight-line distance between two points in a dimensional space defined by data. Two or more sites with very similar values for all data constituents would lie close together in a dimensional space and, therefore, would have

a small Euclidean distance between them and would cluster together. The Ward's method uses and analysis of variance (ANOVA) to measure the cluster differences where the two merged clusters leads to the smallest increase in the sum of the within-group sum of squares (Liao, 2005).

3.3. Results

3.3.1. Overall species richness

The therapeutic reptiles include 135 taxa (Table 2) recorded in 30 countries [Fig. 2; Supplementary Information A (SI A)], of which 101 were identified down to species. Among these species, squamates (n=44) comprising mostly of snakes [colubrids (n=9), elapids (n=12), lamprophiids (n=12), pythons (n=3), boas (n=2), adders (n=5) and typhlopids (n=1)] were the most recorded (Table 2, see SI C for inclusion of taxa not identified beyond genus). In the same order, lizards (n=34) comprising chameleons (n=11), agamas (n=6), girdled lizards (n=5), monitors (n=5), skinks (n=4), plated lizards (n=2) and geckos (n=1) were the second most recorded. Chelonians (n=19) [comprising tortoises (n=8), turtles (n=7) and terrapins (n=4)] and Crocodilians (n=4) were the least recorded orders, respectively. The species richness recorded is in agreement with the natural species richness of the three orders – naturally, there are more squamates than there are Testudines and all the Africa crocodile genera have been recorded as being traded (Table 3). What is more, the complete number of species belonging to one genera were recorded for *Dendroaspis* [four species occur in Africa (Branch 1998)], *Varanus* (five species occur in Africa (Bayless 2002), *Crocodylus* [two species (Bates *et al*., 2014)] and *Mecistops* [one species (Bates *et al*. 2014)]. Snakes comprising colubrids [the most successful and most common snakes with an occurrence all over Africa (Branch 1998)] and lamphrophids [a large clade consisting of approximately 60 genera and 280 species (Vidal *et al*., 2007)] had the highest number of therapeutic species recorded (18 genera, three families and 25 species), followed by chameleons with 12 species from two genera.

The highest numbers of species were recorded in Togo (n=48) and South Africa (n=48 including six non-market records) followed by Mali (n=25, including one non-market record) [Fig. 2]. Angola had non-market taxa (n=2) only that could not be identified to species. Of the 54 countries in Africa, no therapeutic reptiles were recorded in 23 countries including the African islands.

Table 2. The count breakdown of reptile taxa recorded for therapeutic purposes in 30 African countries.

	All records	Market records	No of countries reporting market observations
Records identified down to order	6	6	6
Reptiles identified down to family	6	5	10
Reptiles identified down to genus	22	21	13
Reptiles identified down to species	101	88	25
Total records	**135**	**120**	**-**

Table 3. The hierarchical count breakdown of reptile taxa per order recorded for therapeutic purposes in 30 African countries.

	All records			Market records		
Order	No. families per order	No. genera per order	No. species per order	No. families per order	No. genera per order	No. species per order
Crocodylia	1	3	4	1	3	4
Squamata	14	41	82	12	32	66
Testudines	5	15	20	5	14	18
Total	**20**	**59**	**106***	**18**	**49**	**88**

* Includes five reptile taxa with unique genera and family counted as a species.

Of the 54 countries recognised by the African Union (AU, 2017), no therapeutic reptiles were recorded in 26 countries [see glossary page; see also Fig. 2 for map layout (excluding islands)]. West Africa had the most number of therapeutic species followed by southern Africa (Fig. 3). Regionally, West Africa had the most number of therapeutic species followed by southern Africa. Only Central Africa had the least number of species recorded, all of which were non-market records.

3.3.2. Species similarity

The Sørenson's similarity index indicated the highest similarity (based on the high number of shared species) between reptile species recorded in West Africa – Mali vs. Togo (49%), Mali vs Niger (61%), Nigeria vs Niger (52%) and Benin vs Mali (42%) [Table 4]. The highest mean percentage and the standard deviation closer to the mean percentage similarity was obtained for southern Africa (mean value=44; Stdev=±39) and Central Africa (33; ± 28), indicating the least variability of percentage similarity of species in the two regions (Table 5). Conversely, West Africa showed the highest species variability.

Of the four southern African countries (Swaziland, Namibia, Botswana and South Africa) recorded, at least two countries shared a minimum of two species resulting in a similarity range of 9% - 100%. In Central and North Africa, the lowest number of species records resulted in

some countries not having any species in common (similarity ranges of zero to maximum). Therefore, the highest mean percentage similarity of species was obtained between countries in southern Africa (44%) followed by West Africa (36%), with the least mean percentage similarity obtained for southern Africa and Central (8%) [Table 6]

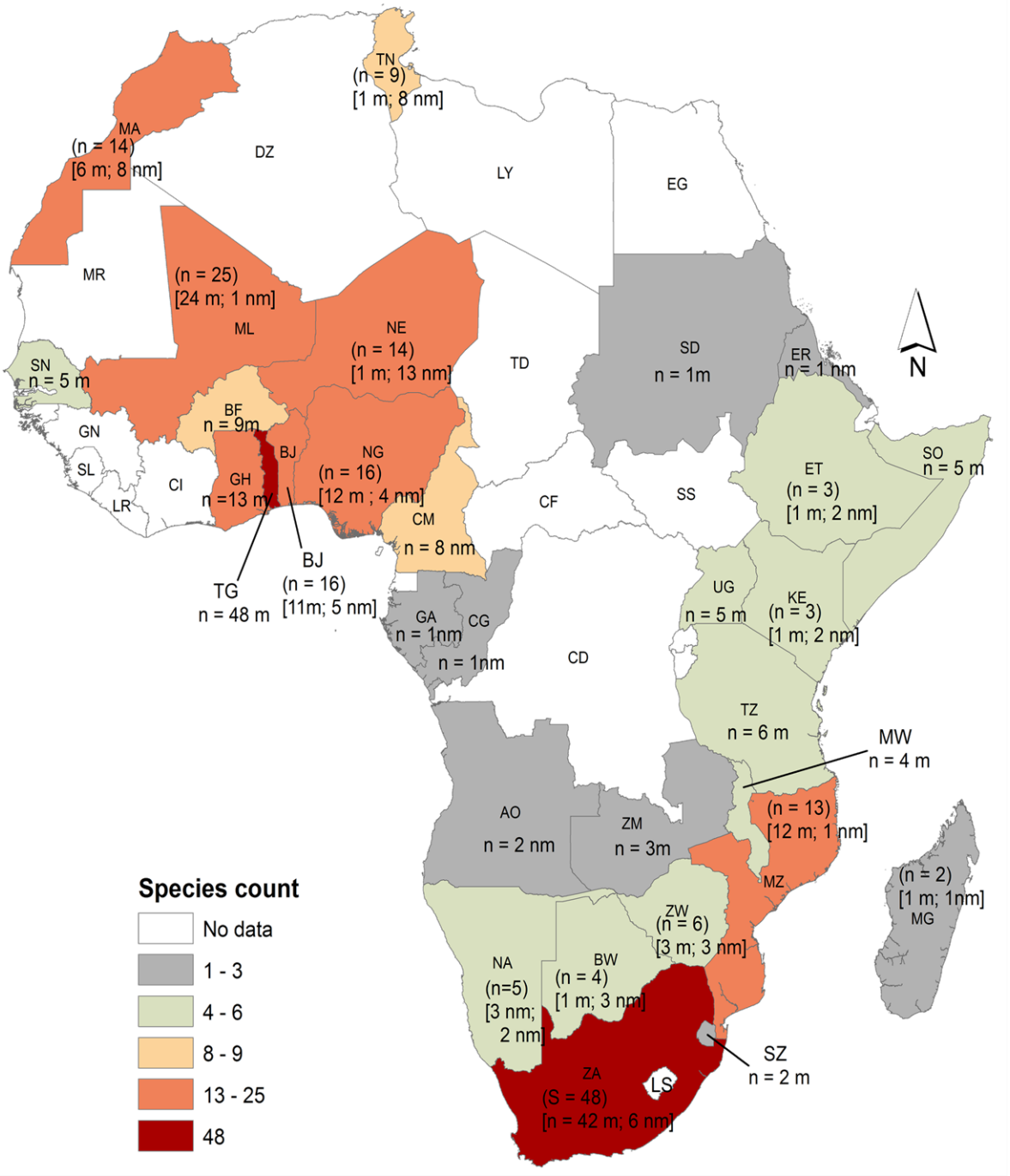

Figure 2. The total number of therapeutic reptile species recorded (nm=non-market; m=market) across 30 African countries. The counts include the reptiles that could not be identified beyond genus but were considered based on their exclusiveness per country. ISO country codes definitions are given in the glossary.

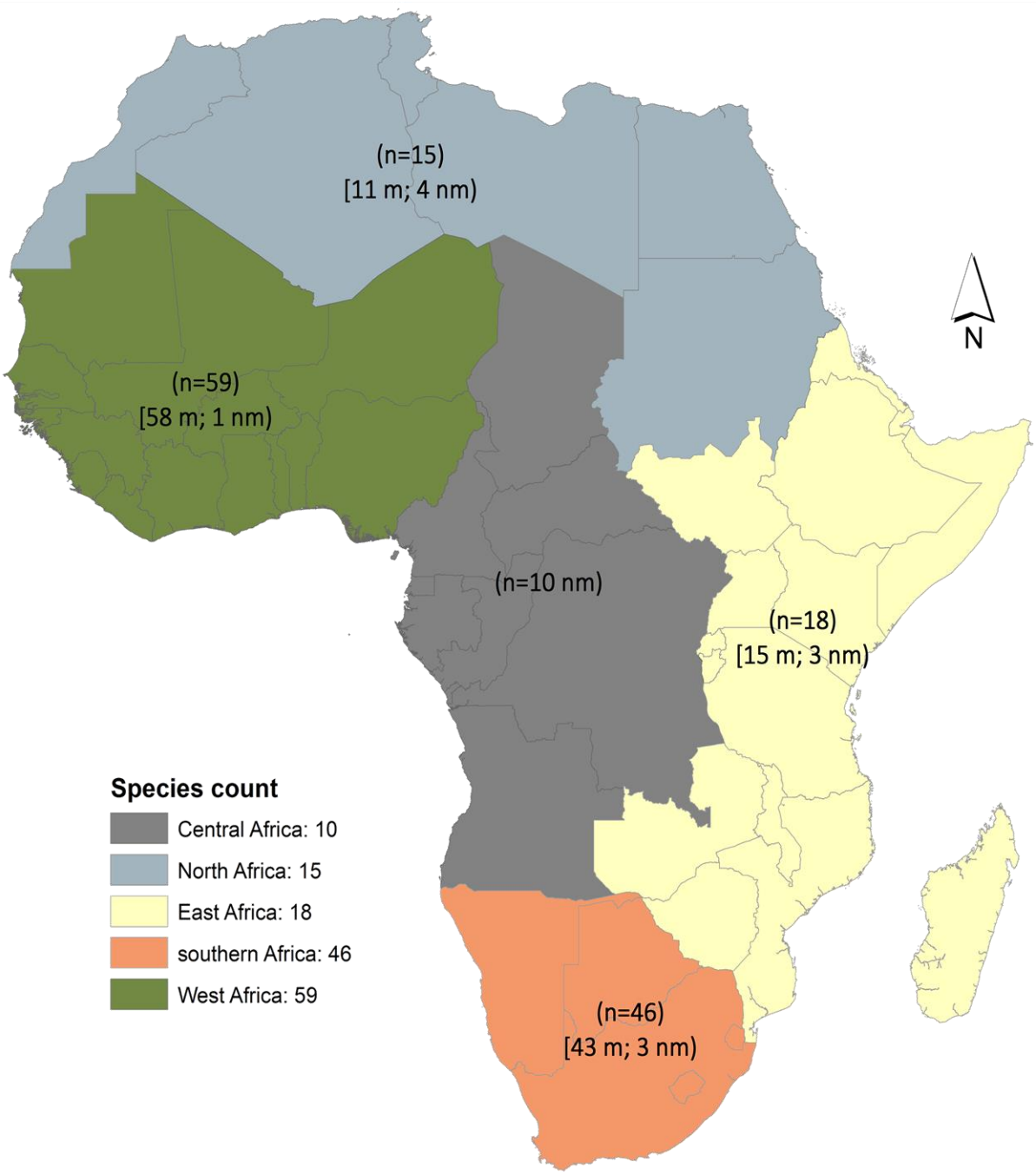

Figure 3. The total number of therapeutic reptile species recorded (nm=non-market; m=market) across 30 African countries. The counts include the reptiles that could not be identified beyond genus but were considered based on their exclusiveness per region.

Table 4. Sørenson similarity analysis of species recorded for therapeutic purposes in Africa. The species percentage similarity is based on the most number of shared species observed for the two countries being compared. Taxa identified to genus and family only (e.g. '*Naja spp*' or 'unidentified mamba') were excluded. The full comparison table of species similarity is given in SI D.

Region A	Region B	Country A	Country B	Sørenson similarity %	No. of shared species	No. of species in country A	No. of species in country B
West	West	Mali	Togo	49%	16	22	44
West	West	Mali	Niger	61%	11	22	14
West	West	Nigeria	Niger	52%	7	13	14
West	West	Benin	Mali	42%	7	11	22
North	North	Morocco	Tunisia	80%	6	9	6
West	West	Mali	Ghana	40%	6	22	8
West	West	Niger	Senegal	53%	5	14	5
West	West	Niger	Burkina Faso	46%	5	14	8
West	West	Benin	Niger	40%	5	11	14
East	East	Kenya	Ethiopia	80%	4	5	5
West	West	Nigeria	Senegal	44%	4	13	5
East	South	Malawi	Namibia	75%	3	4	4
East	East	Ethiopia	Malawi	67%	3	5	4
East	South	Ethiopia	Namibia	67%	3	5	4
East	East	Kenya	Malawi	67%	3	5	4
East	West	Ethiopia	Senegal	60%	3	5	5
East	West	Kenya	Senegal	60%	3	5	5
Central	West	Cameroon	Senegal	50%	3	7	5
East	East	Mozambique	Malawi	43%	3	10	4
East	East	Mozambique	Kenya	40%	3	10	5
East	East	Mozambique	Somalia	40%	3	10	5
East	East	Mozambique	Zimbabwe	40%	3	10	5
Central	West	Cameroon	Ghana	40%	3	7	8
East	southern	Kenya	Namibia	44%	2	5	4
East	South	Zimbabwe	Namibia	44%	2	5	4
East	West	Malawi	Senegal	44%	2	4	5
East	East	Malawi	Zimbabwe	44%	2	4	5
East	East	Ethiopia	Zimbabwe	40%	2	5	5
East	East	Kenya	Somalia	40%	2	5	5

Cluster analysis for species similarity across regions revealed two cluster levels (Fig. 4). In the first level, all regions but North were included and showed 18% species similarity. In the second level, the North region had a 100% similarity with all the other regions. However, East and southern African regions were the most similar in terms of species recorded, with a similarity level of 39%. West Africa was the most similar to East and southern African regions with 25% and Central followed with approximately 18% similarity.

Table 5. The Sørenson percentage similarity of species per region. This similarity analysis is based on SI D.

Subregions	% Similarity: range	% Similarity: mean* ± stdev	No. shared species: range	Total no. of species: sub region	No. of countries in the region
Central	0-100	33 ± 18	0-1	8	3
North	0-80	33 ± 28	0-6	9	3
East	20-80	27 ± 20	0-4	18	11
West	19-61	36 ± 10	2-16	56	8
southern	9-100	44 ± 39	2-4	45	4

* Mean based on the total comparison

Table 6. A cross comparison of the Sørenson mean percentage similarity of species in all regions based on SI D.

	Central	**North**	**West**	**East**	**southern**
Central	33%				
North	12%	33%			
West	22%	23%	36%		
East	17%	23%	22%	27%	
southern	8%	29%	23%	30%	44%

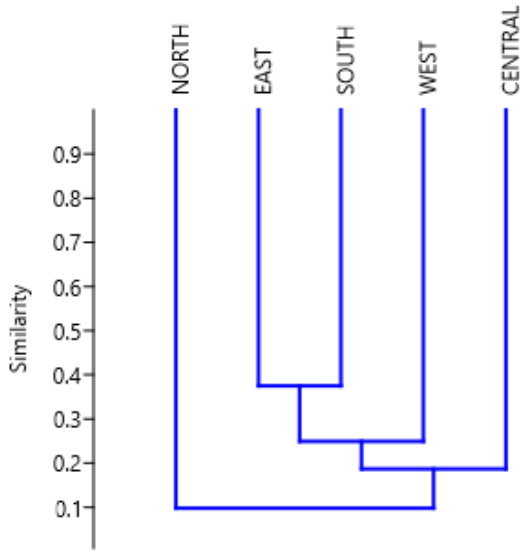

Figure 4. Cluster analysis dendrogram derived from therapeutic species in the African regions using Sørenson similarity index.

3.3.3. Morphospecies similarity

When evaluating the similarities of morphospecies, West African countries vs. South Africa showed the highest similarity [Table 7]. This is plausible since South Africa had the most number of species recorded in together with some of the countries in West Africa; hence, the highest number of species shared between them. Similarly, western countries showed the highest morphospecies similarities due to the high number of shared species among them. West and southern Africa had the highest number of morphospecies recorded (n=59 and n=46, respectively), the highest minimum mean percentage similarities (31% and 13%, respectively) and the highest minimum number (n=2) of shared species (Table 8). Although the highest mean percentage similarity was obtained for West Africa (70% ± 15), East Africa (47% ± 26) and southern Africa, their calculated standard deviation values lie further from their respective means indicating the variability of morphospecies values within these regions. Conversely, North and Central Africa showed the least variability of morphospecies values within the regions. The highest mean percentage similarity was obtained for southern Africa vs West Africa (59%) and the least mean percentage similarity was obtained for North Africa vs Central Africa (18%) [Table 9]. All regions showed morphospecies percentage similarities greater than 65%, with three regions (West, East and southern Africa) showing similarities greater than 85% (Fig. 5).

Table 7. Sørenson similarity analysis of morphospecies recorded for therapeutic purposes in Africa. The species percentage similarity is based on the most number of shared morphospecies observed for the two countries being compared. Taxa identified to genus and family only (e.g. '*Naja spp*' or 'unidentified mamba') were included. The full comparison table of species similarity is given in SI E.

Region A	Region B	Country A	Country B	Sørenson similarity %	No. of shared species	No. of species in country A	No. of species in country B
South	West	South Africa	Togo	90%	16	13	13
South	West	South Africa	Benin	77%	16	10	10
South	West	South Africa	Nigeria	77%	16	10	10
South	West	South Africa	Mali	74%	16	11	10
South	West	South Africa	Niger	69%	16	10	9
South	West	South Africa	Ghana	69%	16	10	9
South	West	South Africa	Burkina Faso	61%	16	7	7
West	West	Togo	Niger	78%	13	10	9
West	West	Togo	Ghana	78%	13	10	9
West	West	Togo	Burkina Faso	70%	13	7	7
West	West	Mali	Niger	86%	11	10	9
West	West	Mali	Togo	83%	11	13	10
West	West	Mali	Burkina Faso	78%	11	7	7
West	West	Mali	Nigeria	76%	11	10	8
West	West	Mali	Ghana	76%	11	10	8
West	West	Benin	Nigeria	90%	10	10	9
West	West	Nigeria	Niger	90%	10	10	9
West	West	Niger	Ghana	90%	10	10	9
West	West	Benin	Togo	87%	10	13	10
West	West	Nigeria	Togo	87%	10	13	10
North	North	Morocco	Tunisia	82%	10	7	7
West	West	Benin	Niger	80%	10	10	8
West	West	Nigeria	Ghana	80%	10	10	8
North	West	Morocco	Togo	78%	10	13	9
West	West	Benin	Mali	76%	10	11	8
North	West	Morocco	Nigeria	70%	10	10	7
North	West	Morocco	Niger	70%	10	10	7
North	West	Morocco	Ghana	70%	10	10	7
West	West	Benin	Ghana	70%	10	10	7
North	South	Morocco	South Africa	69%	10	16	9
North	West	Morocco	Mali	67%	10	11	7
East	South	Mozambique	South Africa	72%	9	16	9
East	West	Mozambique	Mali	70%	9	11	7
East	West	Mozambique	Togo	64%	9	13	7

Table 8. The Sørenson percentage similarity of morphospecies per region. This similarity analysis is based SI E.

Subregions	% Similarity: range	% Similarity: mean* ± stdev	No. shared morphospecies: range	Total no. of morphospecies: sub region	No. of countries in the region
Central	0-100%	21 ± 20	0-1	10	4
North	0-82%	34 ± 25	0-7	15	3
East	0-100	47 ± 26	0-5	18	11
West	31-90	70 ± 15	2-10	59	8
southern	13-67	46 ± 12	2-6	46	4

* Mean based on the total comparison

Table 9. A cross comparison of morphospecies mean percentage similarity in all regions based on SI E.

	Central	North	West	East	southern
Central	21%				
North	18%	34%			
West	45%	58%	70%		
East	33%	42%	50%	47%	
southern	27%	39%	59%	46%	46%

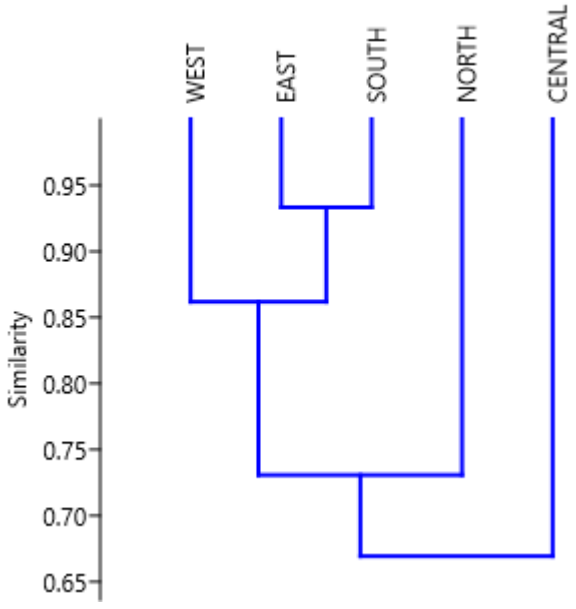

Figure 5. Cluster analysis dendrogram derived from the morphospecies in the African regions using Sørensen similarity index.

3.4. Discussion and conclusion

Of the global 10 450 reptile species, of which 1 645 (16%) were recorded in Africa (Uetz *et al*., 2016), at least a substantial amount (n=106; 1% of global species and 6% of African species) have been recorded as being therapeutic and the majority are traded in traditional medicine market across the continent. This figure could be an underestimation of the real state of the affairs while demonstrating the need to assess the implication of the reptile trade for therapeutic purposes. The paucity of information in Central, East and North Africa limits the data and warrants further investigation. Regardless of the affluence of data in West and southern Africa, the within region countries also warrant further investigations. The selection of reptile for therapeutic purposes is often at morphospecies level; hence, the countries and regions were most similar in terms of recorded morphospecies than individual species. Nevertheless, countries in the West region had the greatest number of species recorded and were most similar in this regard. It is necessary to obtain additional data of reptiles traded from countries that lacked data to give a better similarity overview.

This is the first richness and similarity analysis of reptiles recorded for therapeutic purposes in Africa. However, it is affected by the lack of publicly available data in most African countries and the incomplete taxonomic knowledge of some of the taxa recorded. The lack of available data is exacerbated by the prevalence of ethnobotanical studies and the number of medicines made from plants, which is much higher than the number of medicines made from animal parts (Alves and Rosa, 2010). Regardless, the overview can serve as a starting point to redirect research and conservation efforts. The lack of data for most countries, especially in Central, West and North Africa warrants further investigations.

The general lack of therapeutic reptile data for Africa is apparent when we compared with the number of reptiles species reported in the global quantitative assessment in Alves *et al*., (2013) sourcing mostly from Brazilian and Chinese studies (about 60 studies) where 331 reptile species (229 more species than recorded in this report) were recorded (both trade and non-market data) for traditional medicine. However, only two studies (Adeola, 1992 for Nigeria; Highfield and Bayley, 2007 for Morocco) contributed to the global quantitative assessment. Although there are more bird species than there are reptile species (Gaston and Blackburn 1996). A study in Williams *et al*. (2014) recorded 399 avian taxa used and traded for traditional medicine of which 347 taxa were sold in the market and 43 taxa had non-market records.

Although they recorded avian taxa in 25 countries – five less than the countries recorded in this report, they recorded significantly more avian taxa compared to this report. However, this is plausible because there are more bird species than there are reptile species (see Gaston and Blackburn 1995). Similarly, Williams *et al*. (2014) recorded most species in West and southern Africa; and paucity in other African regions highlighting a general lack of bird data traded in markets. In terms of similarity analysis, Williams *et al*. (2014) obtained a similar similarity pattern obtained in this report where the similarity of bird species was highest between the western countries (i.e. Benin and Nigeria; 53% similar) and lowest between Nigeria (West) vs South Africa (southern) [27% similar]. Similarly, for morphospecies, southern Africa and West Africa had the highest morphospecies similarity regardless of their geographical differences.

The importance of therapeutic reptiles is highlighted in studies that continue to record the availability of reptiles in the markets, and the lack of data of traded species is highlighted by the small number of documented species perhaps due to efforts aimed to protect some species through legislations. The report has answered the questions pertaining to the number of reptiles species recorded for therapeutic purposes and the countries and/ or regions the reptile species are traded in. This report, therefore, serves as a starting point for future researchers willing to research further.

Chapter 4

4. Patterns of Rarity and commonness

4.1. Introduction

About 19% of the global reptiles are Threatened with extinction, of which 12% are categorised on the IUCN Red List as Critically Endangered, 41% Endangered and 47% Vulnerable (IUCN, 2013). In Africa, about 50% of described reptiles have published assessments (Bates *et al*., 2014; Tolley *et al*., 2016), of which most were categorised based on ranges size (Rabinowitz category B; see Table 1) [Tingley *et al*., 2016]. The determination of species rarity requires fairly less information on the population than the categorisation of threat status but could include species with natural rarities without major threats (Gaston and Blackburn, 1995). There are many ways to designate common and rare species in relation to their position on a rank abundance plot.

Studies of rarity are important because they highlight species that could be rare and in need of conservation efforts (Caughley, 1994; Brown, 1995) and for the comparison between rare and common species (McCoy and Mushinsky, 1992; Dobson and Yu, 1993). It should be noted that rarity on its own does not cause extinctions; the collision of human impacts (e.g. direct offtakes) with rarity susceptibilities can cause extinctions (Sodhi and Erhlich, 2010). Species extinctions concentrates where human actions impact concentrations of small-ranged species, otherwise, human impacts will have a relatively little effect (Myers *et al*., 2000). This chapter examines rarity and commonness of therapeutic reptile species in Africa by following Rabinowitz (1981) and Rabinowitz *et al*. (1986) rarity classification coupled with the adapted model of Yu and Dobson (2000).

4.2. Materials and methods

4.2.1. Patterns of rarity or commonness

The recorded therapeutic species (n=101; Table 2) were assigned the Rabinowitz rarity categories from A – H and the coherent Yu and Dobson's mean rarity rank were applied to the data following Table 1. From this assignation, the mean rarity value for morphospecies were also determined based on the rarity values of species *x* and species *y* if they are similar typologically. Similarly, the mean rarity values of species per country and region were

determined. We aimed to compare the rarity classification quantitatively with the criteria used in assessing extinction risk of species [i.e. Population size; geographic ranges (extend of occurrence and area of occupancy); and population size trajectory (whether increasing, stable or declining)] following an approach set out in Williams *et al*. (2014) for birds. Given the nature of the biological and population information available for reptiles, only 46% of reptile species have been risk-assessed by IUCN (IUCN 2016), the report settled for borderline extinction risk judgements.

Given a large number of species recorded for therapeutic purposes:

- Only Threatened species (species listed on the IUCN Red List as Threatened with extinction) and species which tend to be rarest and were assigned category H (rank 1) were identified. However, references are made in SI A and Supplementary Information B (SI B) which included all the species morphospecies recorded and their rarity values, respectively – including their IUCN Red List statuses and CITES Appendices to date.
- Providing the Southern African Reptile Conservation Assessment (SARCA) recommended status in Bates *et al*. (2014) of species that are endemic to South Africa or the southern African region. Bates *et al*. (2014) contains the up-to-date comprehensive and conservation assessment of reptiles in South Africa, Lesotho and Swaziland.

4.3. Results

Of the total 101 therapeutic reptiles identified to species, 40 species are included in the IUCN Red List [Table 4], 11 are Threatened with extinction and 44 are found in either CITES appendix I or appendix II (Table 11). The chameleons showed the highest number of species included in the IUCN Red List (n=9) and in the CITES appendices (n=11), with seven species in the category Least Concern (LC) and two in the outdated Lower Risk/ Near Threatened (LR/NT) categories. These were followed by turtles (n=6) which were all listed in IUCN Threatened categories [Critically Endangered; Endangered; Vulnerable; Near Threatened; Least Concern] and CITES appendix I with the exception of *Cyclanorbis senegalensis* (Senegal flapshell turtle) which is CITES appendix II listed. The patterns of rarities of the total therapeutic species differed per rarity category.

Category A

The category comprised the highest number (n=30) of species which tend to be very common and locally abundant, in several habitats and over a large geographic area. (Tables 10 and 11). Although most species (n=22) are categorised as NE, at least seven species assigned this category are Threatened. Only *Testudo graeca* (spur-thighed tortoise) is Threatened and categorised as VU.

Table 10. The total number of species recorded for therapeutic purposes per rarity category (A-H, see Table 1) and IUCN Red List status.

	Threatened with extinction							
Rarity	CR	EN	VU	NT	LC	DD	NE	**TOTAL**
A			1		7		22	30
B		1	2		5		13	21
C							4	4
D	2		3		1	1	6	13
E					4		4	8
F			2	1	7		9	19
G					1		1	2
H				1	1		2	4
TOTAL	**2**	**1**	**8**	**2**	**26**	**1**	**61**	**101**

CR=Critically Endangered; EN=Endangered; VU=Vulnerable; NT=Near Threatened; LC=Least Concern; DD=Data Deficient; NE=Not Evaluated

Category B

The category comprised the second highest number of species (n=21) which tend to be intermediately common and locally abundant, in specific habitats and over a large geographic area (Tables 10 and 11). Three species are Threatened [both *Caretta caretta* (loggerhead turtle) and *Lepidochelys olivacea* (olive riddle turtle) are categorised as VU; *Chelonia mydas* (green turtle) is categorised as EN], five are categorised as LC and 13 as NE.

Category C

The category comprised four species, which tend to be intermediately common and constantly sparse, in several habitats and over a large geographic area (Tables 10 and 11). These four species are categorised as NE.

Category D

The category comprised 13 species that tend to be rare and constantly sparse, in specific habitats and over a large geographic area (Tables 10 and 11). Five of these species, are Threatened [both *Mecistops cataphractus* (African slender snouted crocodile) and *Eretmochelys imbricata* (hawksbill turtle) are categorised as CR; *Osteolaemus tetraspis* (African dwarf crocodile), *Dermochelys coriacea* (leatherback turtle) and *Centrochelys sulcata* (African spurred tortoise) are categorised as VU].

Category E

The category comprised eight species which tend to be intermediately common locally abundant, in several habitats and over a small geographic area (Tables 10 and 11). None of these species are Threatened.

Category F

The category comprised the third highest number (n=19) of species which tend to be rare and locally abundant, in specific habitats and over a small geographic area (Tables 10 and 11). Two of these species are categorised as Threatened [both *Smaug giganteus* (Sungazer) and *Cyclanorbis senegalensis* (Senegal flapshell turtle) are categorised as VU]. Most of these species (n=9) in this category are categorised as NE.

Category G

The least recorded species (n=2) were classified and are not categorised as Threatened (Tables 10 and 11). These species tend to be rare and constantly sparse, in several habitats and over a small geographic area.

Category H

This category comprised the rarest species (n=4) which tend to be constantly sparse, in specific habitats and over a small geographic area (Tables 10 and 11). However, none of the species are Threatened.

Table 11. The 101 species recorded for therapeutic purposes and their assigned rarity categories and ranks based on table 1. The species includes their global IUCN Red List and CITES Appendix listing (**I** or **II**)[b] in brackets.

Geographic Range		Large		Small	
population size		Large, dominant somewhere	Small, non-dominant	Large, dominant somewhere	Small, non-dominant
		A (4)	**C (3)**	**E (3)**	**G (2)**
Habitat specificity	*Wide*	*Acanthocercus atricollis* LC II *Bitis arietans* *Boaedon capensis* *Boaedon fuliginosus* *Causus rhombeatus* *Chamaeleo dilepis* II *Dispholidus typus* *Gerrhosaurus flavigularis* *Hemidactylus mabouia* *Naja katiensis* LC *Naja melanoleuca* *Naja mossambica* *Naja nigricollis* *Naja nivea* *Philothamnus irregularis* LC *Psammophis mossambicus* *Psammophis phillipsii* *Psammophis sibilans* *Psammophylax tritaeniatus* LC *Pseudaspis cana* *Python natalensis* II *Python sebae* II *Stigmochelys pardalis* LC II *Testudo graeca* VU* II *Trachylepis perrotetii* *Trachylepis striata* *Uromastyx acanthinura* II *Varanus albigularis* II *Varanus exanthematicus* LC II *Varanus griseus* I	*Kinixys spekii* II *Naja annulifera* *Naja haje* *Rhamphiophis oxyrhynchus*	*Afrotyphlops bibronii* LC (SARCA) *Agama agama* LC *Chersina angulata* II *Dasypeltis gansi* *Eumeces algeriensis* LC *Hemachatus haemachatus* LC *Psammophylax rhombeatus* *Thelotornis capensis* LC	*Chamaeleo calcaricarens* LC II *Cordylus jonesii* II

		B (3)	D(2)	F (2)	H (1)
	Narrow	*Bitis gabonica* *Bitis nasicornis* *Broadleysaurus major* *Caretta caretta* VU **II** *Chamaeleo africanus* LC **II** *Chamaeleo gracilis* LC **II** *Chamaeleo senegalensis* LC **II** *Chelonia mydas* EN **II** *Crocodylus niloticus* LC* **I**/ **II** *Crocodylus suchus* *Dendroaspis jamesonii* *Grayia ornata* *Grayia smithii* *Lepidochelys olivacea* VU **II** *Pelomedusa subrufa* *Pelusios castaneus* *Python regius* LC **II** *Thelotornis kirtlandii* *Toxicodryas blandingii* *Varanus niloticus* **II** *Pelusios sinuatus*	*Calabaria reinhardtii* **II** *Centrochelys sulcata* VU* **II** *Dendroaspis polylepis* LC *Dermochelys coriacea* VU **I** *Eretmochelys imbricata* CR **I** *Gongylophis muelleri* **II** *Hapsidophrys smaragdina* *Kinixys erosa* DD **II** *Kinixys zombensis* *Mecistops cataphractus* CR **I** *Osteoelamus tetraspis* VU* **II** *Trapelus mutabilis* *Trionyx triunguis* **II**	*Acontias plumbeus* LC *Agama impalearis* LC *Agama mwanzae* LC *Bitis rhinoceros* *Bradypodion dracomontanum* NT (SARCA) **II** *Bradypodion melanocephalum* VU (SARCA) **II** *Bradypodion setaroi* LC **II** *Bradypodion thamnobates* VU (SARCA) **II** *Chamaeleo chamaeleon* LC **II** *Cordylus cordylus* **II** *Cordylus vittifer* **II** *Cyclanorbis senegalensis* VU **II** *Dendroaspis viridis* LC *Lycodonomorphus laevissimus* *Lycodonomorphus rufulus* *Pelusios niger* LC *Smaug giganteus* VU* **II** *Smaug warreni* **II** *Varanus ornatus* **II**	*Bradypodion nemorale* NT (SARCA)**II** *Dendroaspis angusticeps* *Kinixys homeana* **II** *Lamprophis aurora* LC

[a] Red List status: CR=Critically Endangered; EN=Endangered; VU=Vulnerable; NT=Near Threatened; LC=Least Concern; DD=Data Deficient.

[b] CITES listing: Appendix **I** includes species threatened with extinction and their trade is permitted only in exceptional circumstances. Appendix **II** includes species that are not necessarily threatened with extinction, but in which their trade must be controlled to avoid uses incompatible with their survival.

The CITES Appendix status of *Crocodylus niloticus* is **I** or **II** depending on the region it occurs in.

* denotes 1996 IUCN statuses requiring an update.

4.3.1. Patterns of rarity in morphospecies

The 101 therapeutic species comprised 18 morphospecies groups (Fig. 6a,b; SI A). However, the mean rarity rank of 2.97 indicates that the 18 morphospecies recorded tend to be generally rare (Fig. 6a,b). The morphospecies groups were not homogenously spread out among the rarity categories and rarity ranks.

4.3.1.1. Rare morphospecies

4.3.1.1.1. Spiny/girdled lizards

The genus *Cordylus* comprises 21 species and *Smaug* comprises six species (Bates *et al.*, 2014). However, five species (three from *Cordylus* and two from *Smaug*) were recorded (SI A). Only the South African endemic *S. giganteus* is Threatened and listed as VU both globally (IUCN Red List) and locally (SARCA). Moreover, only *Cordylus cordylus* (Cape girdled lizard) which is near-endemic to South Africa has a global LC recommendation in Bates *et al.* (2014), therefore the species is not of a conservation concern. The three other recorded girdled lizards are also near-endemic to South Africa and are listed under SARCA as LC, however, they are of a global conservation concern as they are CITES Appendix II listed. Four species were assigned rarity category F (rank 2) and one species was assigned rarity category G (rank 2) [Table 11; Fig. 6a,b] and had a mean rarity rank of 2.00 - indicating that they are generally rare.

4.3.1.1.2. Boas

Two Boidae species were recorded (SI A). Although both are not globally Threatened, they are of a global conservation concern, as they are CITES Appendix II listed. Both these species were assigned rarity category D (rank 2) [Table 11; Fig. 6a,b], and tend to be generally rare with a mean rarity rank of 2.00.

4.3.1.1.3. Mambas

All four species in the genus *Dendroaspis* (Branch, 1998) were recorded (SI A). None of these mambas are Threatened or are of a conservation concern. However, only *D. angusticeps* tends to be rarest and was assigned rarity category H (rank 1) [Table 11; Fig. 6a,b]. The other three mambas were each assigned rarity category D, E and F. The mean rarity rank of 2.00 indicates that these mambas tend to be generally rare.

4.3.1.1.4. Chameleons

The genus *Chamaeleo* contains 14 species in Africa and *Bradypodion* contains 17 species (Uetz, 2016) – fifteen of which are endemic to South Africa and two are semi-endemic (Bates *et al*., 2014). Eleven species were recorded from *Bradypodion* (five species) and genus *Chamaeleo* (six species) [SI A]. Of the five *Bradypodion* species, four species (*B. nemorale*; *B. thamnobates*; *B. dracomontanum*; *B. melanocephalum*) are endemic to South Africa and *B. setaroi* is near-endemic to South Africa (Bates *et al*., 2014). None of these chameleons are Threatened globally, but all are of a conservation concern as they are CITES Appendix II listed. Of the endemic *Bradypodion* species, SARCA recommends a global status upgrades from NT to VU for both *B. melanocephalum* and *B. thamnobates*; and NE to NT for *B. dracomontanum*. Moreover, of the eleven chameleons recorded, only *B. nemorale* tends to be rarest and was assigned rarity category H (rank 1) [Table 11; Fig. 6a,b]. Five were assigned rarity category F (rank 2), three were assigned rarity category B (rank 3), and two were assigned rarity category A (rank 4) and category G (rank 2) separately. The mean rarity rank of 2.40 indicates that these chameleons tend to be generally rare.

4.3.1.1.5. Turtles

Seven turtle species were recorded of which six species (*C. caretta*; *C. mydas*; *E. imbricata*; *L. olivacea*; *D. coriacea*; *C. senegalensis*) are Threatened (SI A). However, all these recorded turtles are of a conservation concern as they are CITES Appendix I (five species) and Appendix II listed (two species). Three species were assigned rarity category B (rank 3), three were assigned rarity category D (rank 2), and one was assigned rarity category F (rank 2) [Table 11; Fig. 6a,b]. The mean rarity rank of 2.43 indicates that these mambas tend to be generally rare.

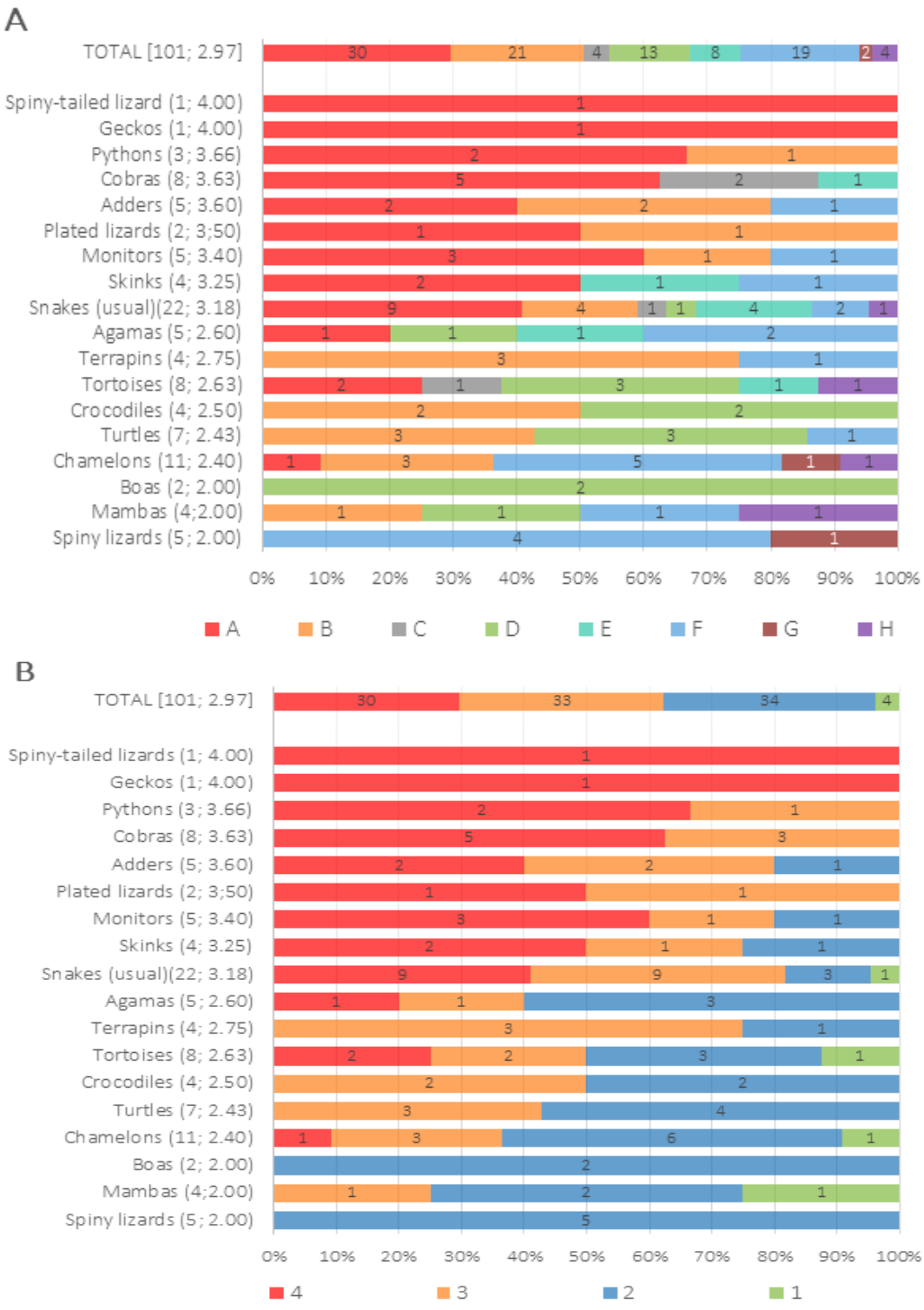

Figure 6. The proportion of reptile species recorded per morphospecies in (**A**) the eight categories and (**B**) the four rarity ranks. The number of species per morphospecies and the mean rarity rank (derived from rarity rank scores in Table 1) are given in parentheses. The mean rarity ranks are given from biggest to smallest in a descending order.

4.3.1.2. Common morphospecies

4.3.1.2.1. Crocodiles

All the three crocodile genera (*Crocodylus*; *Mecistops*; *Osteolamus*) occurring in Africa (Bates *et al.*, 2014) recorded (SI A). *Mecistops cataphractus* and *O. tetraspis* are Threatened and are Appendix I listed. Of the two species that are not Threatened, only *C. niloticus* is CITES Appendix I or Appendix II listed [depending on the country it occurs in (UNEP-WCMC, 2014)], therefore of a conservation concern. The two Threatened crocodile species were assigned rarity category D (rank 2) and the non-Threatened crocodile species were assigned rarity category B (rank 3) [Table 11; Fig. 6a,b]. The mean rarity rank of 2.50 indicates that these crocodiles tend to be generally common.

4.3.1.2.2. Tortoises

Eight tortoise species which included *Chersina angulata* (angulate tortoise) that is near-endemic to South Africa (about 90% range in South Africa and marginal distribution in south-western Namibia) and four of the eight *Kinixys* species in Africa (Bates *et al.*, 2014) were recorded (SI A). Of the eight traded species, only two are Threatened [both *C. sulcata* and *T. graeca* are categorised as (VU)]. All but *K. zombensis* are of a conservation concern and are CITES Appendix II listed. Only *K. homeana* tends to be rarest and was assigned rarity category H (rank 1) [Table 11; Fig. 6a,b]. Three tortoise species were assigned rarity category D (rank 2), two species were assigned rarity category A (rank 4), and two species were assigned rarity category E and C separately. The mean rarity rank of 2.53 indicates that these tortoises tend to be generally common.

4.3.1.2.3. Terrapins

In sub-Saharan Africa where Pelomedusidae is native, the family comprise 19 terrapin species (Branch, 1998). Only four terrapin species from both *Pelomedusa* and *Pelusios* represented in Africa (Bourquin, 2000) were recorded (SI A). None of these terrapin species recorded are of a conservation concern. Three species were assigned rarity category B (rank 3) and one was assigned rarity category F (rank 2) [Table 11; Fig. 6a,b], and had a mean rarity rank of 2.75 – indicating their general commonness.

4.3.1.2.4. Agamas

Of the 47 species of *Agama* occurring in Africa (Wagner *et al*., 2013) only five species were recorded (SI A). None of these agamas are Threatened or are of a conservation concern. Three species were assigned rarity category (rank 2); two in category F and one in category D [Table 11; Fig. 6a,b]. Two species were assigned rarity category A (rank 4) and category B (rank 3) separately. The mean rarity rank of 3.00 indicates that these agamas tend to be generally common.

4.3.1.2.5. Snakes

This morphospecies group comprised the highest species number (n=22) recorded (SI A). These snakes comprise Colubridae species - the most successful and most common snakes with an occurrence all over Africa (Branch, 1998), and Lamprophiidae – a large clade consisting of approximately 60 genera and 280 species (Vidal *et al*., 2007). However, none are Threatened or are of a conservation concern. Only *L. aurora* tends to be rarest and was assigned rarity category H (rank 1) [Table 11; Fig. 6a,b]. Three species were assigned rare rarity categories (rank 2); two in category D and one in category F. Eighteen species were assigned common rarity categories; nine species in category A (rank 4), four species in category B, three species in category E and one species in category C (rank 3). The mean rarity rank of 3.18 indicates that these snakes tend to be generally common.

4.3.1.2.6. Skinks

Four skink species were recorded (SI A). None are Threatened or are of a conservation concern. Two species were assigned rarity category A (rank 4) and two were separately assigned rarity category F (rank 2) and rarity category E (rank 3) [Table 11; Fig. 6a,b]. The mean rarity rank of 3.25 indicates that these skinks tend to be generally common.

4.3.1.2.7. Monitors

All the five monitor species occurring in Africa (Bayless, 2002) were recorded (SI A). Although they are not categorised as Threatened, all are of a conservation concern, as they are Appendix II listed with *V. griseus* being Appendix I listed. Three monitor species were assigned rarity category A (rank 4) whereas two were assigned rarity category B (rank 3), and

rarity category F (rank 2) separately [Table 11; Fig. 6a,b]. The mean rarity rank of 3.40 indicates that these monitors tend to be generally common.

4.3.1.3. Very common species

4.3.1.3.1. Plated Lizards

Two plated lizards [*Broadleysaurus major* (rough scaled plated lizard) and *Gerrhosaurus flavigularis* (yellow throated plated lizard)] were traded (SI A). None are Threatened or are of a conservation concern. These plated lizards were assigned rarity category A (rank 4) and category B (rank 3) respectively [Table 11; Fig. 6a,b], and had a mean rarity rank of 3.50 – indicating that they generally tend to be very common.

4.3.1.3.2. Adders

Although *Bitis* contains 17 species (Uetz, 2016) and *Causus* contain six species *(*Rasmussen, 2005), only four adders from *Bitis* and one from *Causus* were recorded (SI A). None are Threatened or are of a conservation concern. Four adders were assigned common rarity categories; two in category A (rank 4) and two in category B (rank 3). One adder was assigned a rarity category F (rank 2) and tends to be rare [Table 11; Fig. 6a,b]. The mean rarity rank of 3.60 indicates that these adders tend to be generally very common.

4.3.1.3.3. Cobras

Of the fifteen *Naja* species occurring in Africa (Wallach *et al*., 2009), seven species were recorded (SI A). Additionally, a cobra-like elapid *Hemachatus haemachatus* (Rinkhals) - which is usually recognised locally as a separate morphospecies, and is endemic to southern Africa (Alexander and Marais, 2007) was also traded. None of these cobras are Threatened or are of a conservation concern. Eight species were assigned common rarity categories; five in category A (rank 4); two in category C; and one in category E (rank 3) [Table 11; Fig. 6a,b], and had a mean rarity rank of 3.63 – indicating that they generally tend to be very common.

4.3.1.3.4. Pythons

Python is the only genus found in Africa and consists of four species (Bates *et al*., 2014). At least three species were recorded (SI A). Although none of these recorded pythons are

categorised as Threatened, all are CITES Appendix II listed. Two species were assigned rarity category A (rank 3) whereas one was assigned category B (rank 3) [Table 11; Fig. 6a,b], and had a mean rarity rank of 3.66 – indicating that they generally tend to be very common.

4.3.1.3.5. Geckos

Only one gecko [*Hemidactylus mabouia* (Common tropical house gecko)] was used (non-market record) [SI A]. This species is not Threatened or is of a conservation concern. Moreover, the species was assigned rarity category A (rank 4) [Table 11; Fig. 6a,b].

4.3.1.3.6. Spiny tailed lizards

Only *Uromastyx acanthinura* (spiny tailed lizard) was used (non-market record) [SI A]. This species is not Threatened or is of a conservation concern. Moreover, the species was assigned rarity category A (rank 4) [Table 11; Fig. 6a,b].

4.3.2. Patterns of Rarity per Country and Region

4.3.2.1. Central Africa

Eight species were recorded as being used (non-market records) across three countries (Cameroon; Gabon; Congo) [SI B]. Of these, only *O. tetraspis* is Threatened and categorised as VU. Although three species are not Threatened, they are of a conservation concern as they are CITES Appendix II listed (two species) and Appendix I listed (one species). Only *D. angusticeps* tends to be rarest and was assigned a rarity category H (rank 1) [SI B; Fig. 7a,b]. Five species were assigned rarity category B (rank 3), and two were assigned rarity category A (rank 4) and rarity category D (rank 2) separately. The mean rarity rank of 2.75 indicates that these eight species recorded in this region are generally common

4.3.2.1.1. Congo and Gabon

Grayia ornata was the only species recorded to be used in both countries (SI B). The species tend to be intermediately common and was assigned category B (rank 3) [SI B; Fig. 7a,b).

4.3.2.1.2. Cameroon

Seven species of the eight recorded in Central Africa (excluding *G. ornata*) were recorded to be used (SI B). The mean rarity rank of 2.88 indicates that these seven species are generally common (Fig. 7a,b)

4.3.2.2. Southern Africa

Forty-five species were recorded from which three species are Threatened (*S. giganteus*; *C. caretta*; *E. imbricata*) and are CITES Appendix I (two species) and CTES Appendix II listed (one species) [SI B]. However, 18 species that are not Threatened are Appendix II listed. In southern Africa, *C. niloticus* is CITES Appendix II listed except the population of Lesotho and Swaziland which are included in CITES Appendix II (UNEP-WCMC, 2014). Sixteen species were assigned rarity category A (rank 4) and three species (*B. nemorale*; *D. angusticeps*; *L. aurora*) tend to be rarest and were assigned rarity category H (rank 1) [SI B; Fig. 7a, b]. Moreover, eleven species tend to be common (rank 3); therefore three were assigned rarity category B, two were assigned rarity category C and three were assigned rarity category E. Fifteen species tend to be intermediately rare (rank 2); three were assigned rarity category D, 11 were assigned rarity category F and one was assigned rarity category G. The mean rarity rank of 2.75 indicates that these 45 species are generally common.

4.3.2.2.1. Botswana and Swaziland

Crcodylus niloticus and *P. sebae* were recorded in both countries as traded and used, respectively (SI B). Both species are not Threatened globally, however, they are of a conservation concern in both countries and are regionally categorised as VU (Bates *et al.*, 2014). In Swaziland, *C. niloticus* is CITES Appendix I listed but CITES Appendix II listed in Botswana. *Python sebae* is Appendix II listed. *Python sebae* was assigned rarity category A (rank 4) whereas *C. niloticus* was assigned rarity category B (rank 3) [SI B; Fig. 7a, b]. The mean rarity rank of 3.50 indicates that both species are generally very common (Fig. 7a,b).

4.3.2.2.2. Namibia

Four species were recorded (SI B). None are categorised as Threatened and all but one are of conservation concern, as they are Appendix II listed. Two species were assigned rarity category A (rank 4), and two species were assigned rarity category B (rank 3) and rarity category D

(rank 2) separately [SI B; Fig. 7a, b]. The mean rarity rank of 3.25 indicated that the four recorded species are generally common.

4.3.2.2.3. South Africa

All the 45 species recorded in southern African region were recorded in South Africa (SI B), therefore the country richness is similar to the regional richness. However, [*Bradypodion nemorale* (Qudeni dwarf chameleon); *Bradypodion thamnobates* (Midlands dwarf chameleon); *Bradypodion dracomontanum* (Drakensberg dwarf chameleon); *Bradypodion melanocephalum* (KwaZulu dwarf chameleon); *S. giganteus*] are endemic to South Africa and *Bradypodion setaroi* is near endemic to South Africa (Bates *et al*., 2014). Therefore, SARCA recommends a global status upgrades from NT to VU for both *B. melanocephalum* and *B. thamnobates*; and NE to NT for *B. dracomontanum*. For *B. nemorale* and *B. setaroi* (near endemic) and *S. giganteus*, SARCA still recommends the same global IUCN Red List statuses. The mean rarity rank of 2.88 (Fig. 7a,b) indicates that the species tend to be generally common.

4.3.2.3. West Africa

Fifty-six species were recorded of which eight are Threatened (*M. cataphractus*; *O. tetraspis*; *C. mydas*; *E. imbricata*; *L. olivacea*; *D. coriacea*; *C. senegalensis*; *C. sulcata*) [SI B]. Six of the Threatened species are CITES Appendix I listed (including *C. niloticus* in this region) whereas two are CITES Appendix II listed. Of the species that not Threatened, 15 species are of a conservation concern in CITES Appendix II. Twenty-two species were assigned common rarity categories (rank 3) in category B (n=17), category C (n=2), and category E (n=3) [SI B; Fig. 7a,b]. Seventeen species tend to be very common and were assigned rarity category A (rank 4) whereas *K. homeana* tends to be rarest and was assigned rarity category H (rank 1). Sixteen species were assigned rare rarity categories (rank 2) in category D (n=11); and F (n=5). The mean rarity rank of 2.98 indicates that the 46 species are generally common

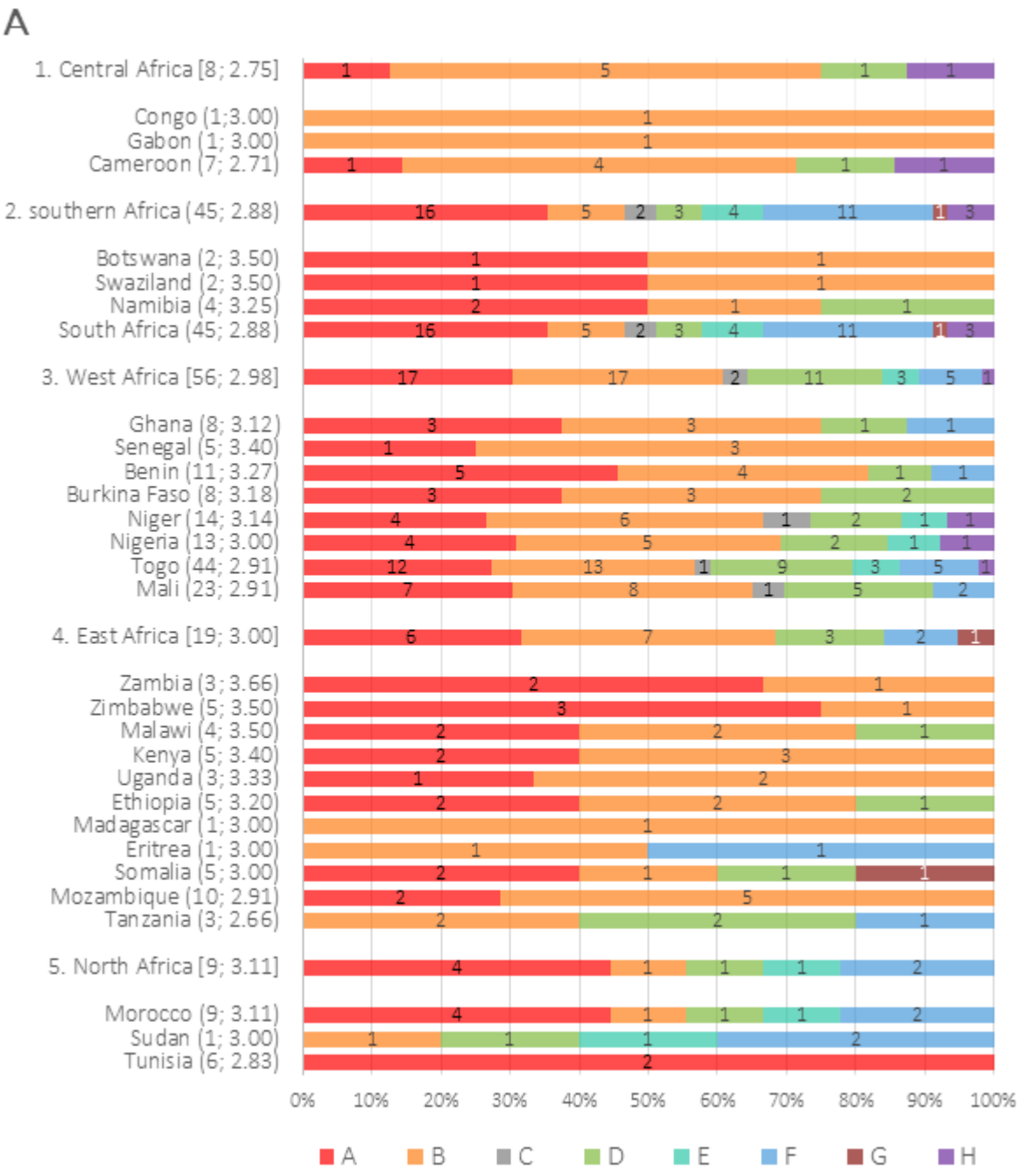

Figure 7a. The proportion of reptile species recorded per country and per region in the eight Rabinowitz categories. The number of species per country, region and the mean rarity rank are given in parentheses, with rank 1 to 4 indicating most to least rare respectively (derived from rank scores in Table 1). The mean rarity ranks are given based on the region's mean rarity ranks from smallest mean rarity to biggest in a descending order.

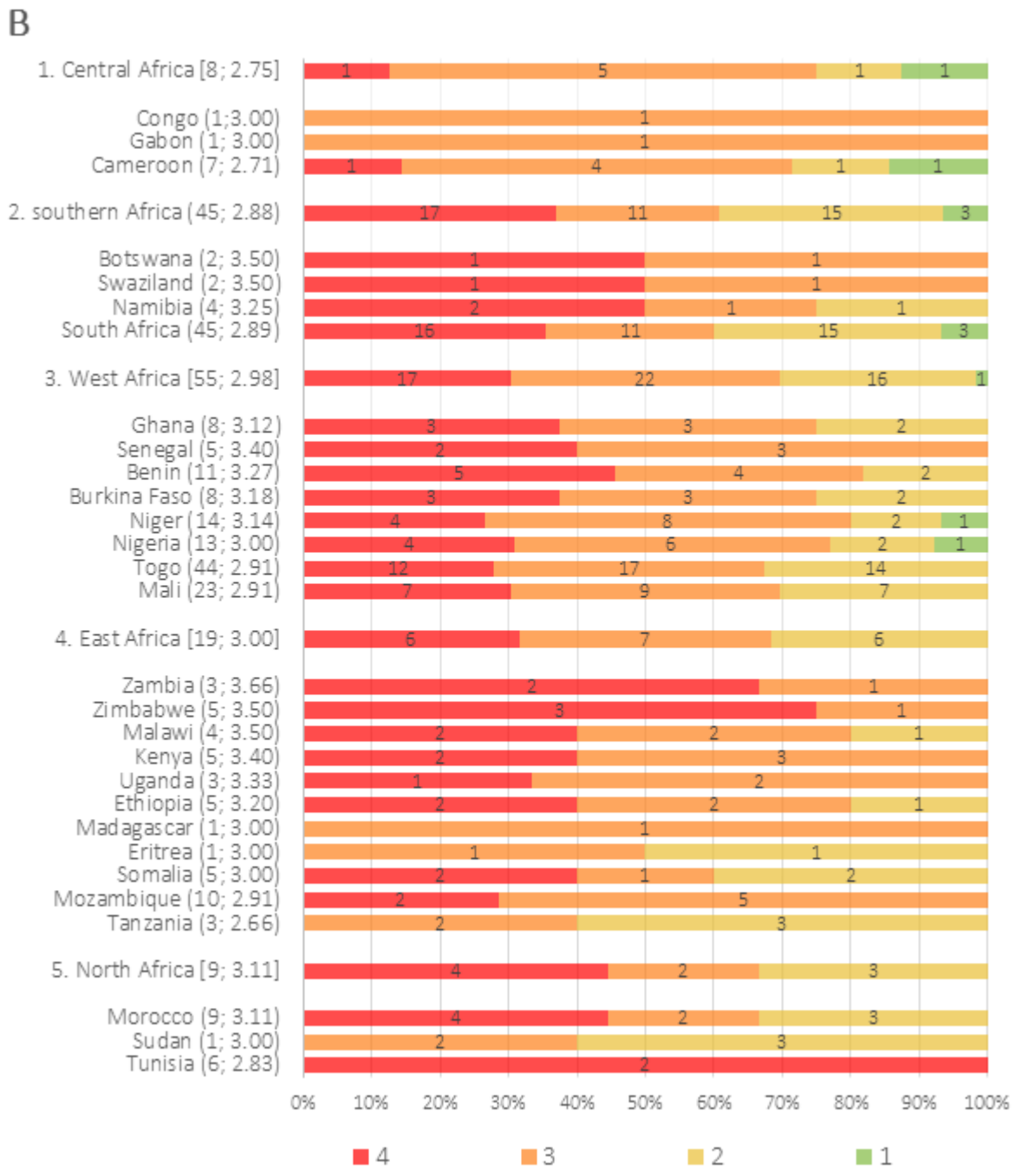

Figure 7b. The proportion of reptile species recorded per country and region in the four Yu and Dobson's rarity ranks. The number of species per country, region and the mean rarity rank (derived from rank scores in Table 1) are given in parentheses. The mean rarity ranks are given based on the region's mean rarity ranks from smallest mean rarity to biggest in a descending order.

4.3.2.3.1. Ghana

Eight species were traded (SI B). None are Threatened but five are Appendix II listed, therefore of a conservation concern. Three species were assigned rarity category A (rank 4) and three were assigned rarity category B (rank 3) [SI B; Fig. 7a,b]. Two species were assigned rarity category D and F separately (rank 2). The mean rarity rank of 3.12 indicates that the eight species tend to be generally common.

4.3.2.3.2. Senegal

Five species were recorded (SI B). None are Threatened, however, C. *niloticus* in this country is CITES Appendix I listed. Moreover, two species are also of conservation concern, as they are CITES Appendix II listed. Four species were assigned rarity category B (rank 3) and one species was assigned rarity category A (rank 4) [SI B; Fig. 7a,b]. The mean rarity rank of 3.40 indicates that these five species traded species traded tend to be generally common.

4.3.2.3.3. Benin

Eleven species were recorded and only *O. tetraspis* is Threatened (SI B). However, two species are of a conservation concern, as they are CITES Appendix II listed. Five species were assigned rarity category A, rank (4) and four were assigned rarity category B, rank 3) [SI B; Fig. 7a,b]. Two species were assigned rarity category D and F (rank 2) separately. The mean rarity rank of 3.27 indicates that these species tend to be generally common.

4.3.2.3.4. Burkina Faso

Eight species were traded of which two (*O. tetraspis*; *C. sulcata*) are Threatened (SI B). Of the six species that are not Threatened, only two are CITES Appendix II listed, therefore are of a conservation concern. Three species were assigned rarity category A (rank 4) and three species were assigned rarity category B (rank 3) [SI B; Fig. 7a,b]. Two species were assigned rarity category D (rank 2). The mean rarity rank of 3.18 indicates that these species tend be generally common.

4.3.2.3.5. Niger

Fourteen species were recorded of which only *C. sulcata* is Threatened and is CITES Appendix II listed (SI B). However, seven species are not Threatened but are Appendix II listed, therefore are of a conservation concern. Eight species tend to be intermediately common (rank 3) and were assigned rarity category B (six species), rarity category E and category C (one species each) [SI B; Fig. 7a,b]. Four species were assigned rarity category 4 (rank 1). The mean rarity rank of 3.14 indicates that the fourteen species tend to be generally common.

4.3.2.3.6. Nigeria

Thirteen species were recorded (SI B). None were Threatened but six species are of a conservation concern as they are Appendix II listed and one is Appendix I listed. Six species tend to be intermediately common (rank 3) and were assigned category B (five species) and one was assigned category E [SI B; Fig. 7a,b]. Three species were assigned rarity category A (rank 4) and two species were assigned rarity category D (rank 2). Only ***K. homeana*** tends to be rarest and was assigned rarity category H (rank 1). The mean rarity rank of 3.00 indicates that these tend to be generally common.

4.3.2.3.7. Togo

Forty-four species which excluded 12 species recorded in regionally (West Africa) were traded (SI B). The eight Threatened species recorded in the region were traded in this country. Of the 36 species that are not Threatened are of a conservation concern, as they are CITES Appendix II listed except *C. niloticus* which is Appendix I listed in this country. Sixteen species tend to be intermediately common (rank 3) and were assigned rarity category B (13 species), rarity category E (two species) and one species in rarity category C (SI B; Fig. 7a,b). Fourteen species tends to be rare (rank 2) and were assigned rarity category D (nine species) and rarity category F (five species). Twelve species were assigned rarity category A (rank 4) and *K. homeana* tends to be rarest and was assigned rarity category H (rank 1). The mean rarity rank of 2.91 indicates that the species traded tend to be generally common.

4.3.2.3.8. Mali

Twenty-two species were recorded (SI B). Of these, Four are Threatened [*M. cataphractus*; *O. tetraspis*; *C. senegalensis*; *C. sulcata*). The Threatened *M. cataphractus* and *O. tetraspis* are

Appendix I listed, and *C. senegalensis* and *C. sulcata* are Appendix listed. Ten species that are not Threatened of a conservation concern as they are Appendix II listed. Eight species tend to be intermediately common (rank 3) in category B (seven species) and one in category C (SI B; Fig. 7a,b). Seven species were assigned rarity category A (rank 4) and seven tend to be rare (rank 2) and were assigned rarity category D (five species) and rarity category F (two species). The mean rarity rank of 2.91 indicated that these species tend to generally common.

4.3.2.4. East Africa

Nineteen species were recorded of which two species [*C. mydas*; *E. imbricata]* are categorised as Threatened and are CITES Appendix I listed (SI B). Of the 17 species that are not Threatened, nine species are of a conservation concern, as they are Appendix II listed and *C. niloticus* is CITES Appendix I listed in the region. Six species tend to be very common and were assigned rarity category A (rank 4) and seven species tend to be intermediately common and were assigned a rarity category B (rank 3) [SI B; Fig. 7a,b]. Six species tend to be rare (rank 2) in category D (three species), one in rarity category G and in rarity category F (two species). The mean rarity rank of 3.00 indicated that the 19 species tend be generally common.

4.3.2.4.1. Zambia

Three species were traded (SI B). Although none are Threatened, both *C. niloticus* and *P. natalensis* are of a conservation concern as they are CITES Appendix II listed. Both *P. natalensis* and *B. arietans* were assigned rarity category A (rank 4) and *B. arietans* was assigned rarity category B (rank 3) [SI B; Fig. 7a,b]. These species are generally very common with a mean rarity rank of 3.66.

4.3.2.4.2. Zimbabwe

Five species were recorded (SI B). Although none are Threatened, they are all of a conservation concern (excluding *D. polylepis* as they are Appendix II listed. Three species were assigned rarity category A (rank 4) and two species were assigned rarity category B (rank 3) and rarity category D separately [SI B; Fig. 7a,b]. These five species are generally very common with a mean rarity rank of 3.50.

4.3.2.4.3. Malawi

Four species were traded (SI B). None are Threatened but all are Appendix II listed, therefore of a conservation concern. Two species were assigned rarity category A (rank 4) and were assigned rarity category B (rank 3) [SI B; Fig. 7a,b]. With their mean rarity rank of 3.50, these species are generally very common.

4.3.2.4.4. Kenya

Five species were recorded of which *S. pardalis* is categorised as Threatened and is Appendix II listed (SI B). All the four species that are not Threatened are CIETS Appendix II listed, therefore are of a conservation concern

Two species were assigned rarity category A (rank 4) and three species were assigned rarity category B (rank 3) [SI B; Fig. 7a,b]. The mean rarity of 3.40 indicates that these species tend to be generally common

4.3.2.4.5. Uganda

Three species were traded (SI B). None are Threatened but two are CITES Appendix II listed, therefore are of a conservation concern. One species was assigned rarity category A (rank 4) and two were assigned rarity category B (rank 3) [SI B; Fig. 7a,b]. The mean rarity of 3.33 indicates that these species tend to be generally common.

4.3.2.4.6. Ethiopia

Five species were recorded (SI B). None of the five species are Threatened, however, four are CITES Appendix II listed, therefore are of a conservation concern. Two species were assigned rarity category A (rank 4) [SI B; Fig. 7a,b]. Two species were assigned rarity category B (rank 3) and one was assigned rarity category (rank 2). The mean rarity of 3.20 indicates that these species to be generally common.

4.3.2.4.7. Madagascar

Only *C. niloticus* was traded (SI B). Although the species is not Threatened, it is CITES Appendix II listed and of a conservation concern. Moreover, this is a common species (category B, rank 3) [SI B; Fig. 7a,b].

4.3.2.4.8. Eritrea

Chelonia mydas was recorded as used (non-market) and is categorised as Threatened (SI B). It is a common species (category B, rank 3) [SI B; Fig. 7a,b].

4.3.2.4.9. Somalia

Five species were traded of which two (*C. mydas*; *E. imbricata*) are categorised as Threatened and are CITES Appendix I listed (SI B). Although three species are not Threatened, they are of a conservation concern, as they are CITES Appendix II listed. Two species were assigned rarity category A (rank 4) [SI B; Fig. 7a,b]. Two species tend to be rare (rank 2) and were assigned rarity category D and category G separately, and one species was assigned rarity category B (rank 3). The mean rarity of 3.00 indicates that these species tend generally common

4.3.2.4.10. Mozambique

Ten species were recorded of which two (*C. mydas*; *E. imbricata*) are categorised as Threatened and are CITES Appendix I listed (SI B). Five species that are not Threatened species are Appendix II therefore are of a conservation concern. Five species were assigned rarity category B (rank 3) and two species were assigned rarity category D (rank 2) [SI B; Fig. 7a,b]. Two species were assigned rarity category A (rank 4) and one species was assigned rarity category F (rank 2). The mean rarity of 2.91 indicates that these species tend to be generally common.

4.3.2.4.11. Tanzania

Three species were traded (SI B). None are Threatened but both species are of a conservation concern as they are CITES appendix II listed. Two species were assigned rarity category B (rank 3) and one species was assigned category F (rank 2) [SI B; Fig. 7a,b]. The mean rarity of 2.66 indicated that these species tend to be generally common.

4.3.2.5. North Africa

Nine species were recorded of which *T. graeaca* is Threatened and is CITES Appendix II listed (SI B). However, five species that are not Threatened are Appendix II listed, therefore are of a conservation concern. Four species tend to be very common and were assigned rarity category A (rank 4) and two species were assigned rarity category F (rank 2) [SI B; Fig. 7a,b]. Moreover,

two species tend to be intermediately common (rank 3) and were assigned rarity category B and rarity category E respectively. The mean rarity of 3.11 indicates that these species tend to be generally common

4.3.2.5.1. Morocco

All the nine species recorded in the region (North Africa) were recorded (SI B).

4.3.2.5.2. Sudan

Only *C. crocodylus* was recorded for trade in the country (SI B). The species tends to be intermediately common (category B, rank 3) [Figure 7a,b].

4.3.2.5.3. Tunisia

Six species were recorded and none are Threatened (SI B). Three species tend to be rare (rank 2) and were assigned rarity category F (two species) and one species was assigned rarity category D [SI B; Fig. 7a,b]. Two species were assigned rarity category A (rank 4) and one species was assigned rarity category B (rank 3). The mean rarity rank of 2.83 indicates that the six species tend to be generally common.

4.3.3. Frequency of species traded for therapeutic purposes

Of the 18 morphospecies recorded, pythons and crocodiles were the most-recorded morphospecies groups in 22 countries each (Fig. 8). None of the morphospecies groups had a mean rank value closer to rarest value of 1; therefore, none is faced with a higher risk of population decline. However, three morphospecies groups (agama lizard; boas; girdled lizard) could be facing a higher or lower risk of population decline with their intermediate mean rarity rank values and records in fewer countries. Seven morphospecies groups (cobras; geckos; plated lizards; skinks; spiny tailed lizards; skinks; terrapins) have a lower risk of population declines due to their records in fewer countries and mean rarity rank values greater than 2 indicating their general commonness. Moreover, seven morphospecies (adders; chameleon; crocodiles; monitor lizards; pythons; turtles; tortoises) were most commonly traded in the most number of countries, therefore had a higher risk of population decline despite their commonness tendencies.

The patterns of rarity differed per species within the morphospecies groups. Four morphospecies groups comprise 14 species that are Threatened with extinction, three (*B. melanocephalum*; *B. thamnobates*; *S.* giganteus) of which are endemic to South Africa and have been evaluated by SARCA (Fig. 9). *Crocodylus niloticus* is the most traded species in 17 countries and a sing non-market country record. This was followed by *V. niloticus* traded in nine countries with non-market records in three countries, followed by *P. sebae* (n=8), *P. suchus* (n=7), *P. natalensis*, *B. arietans* and *S. pardalis* with six countries each. All the Threatened species were recorded in less than four countries, possibly highlighting their serious off-takes from the wild for therapeutic purposes or stringent conservation measures put out against their overutilization.

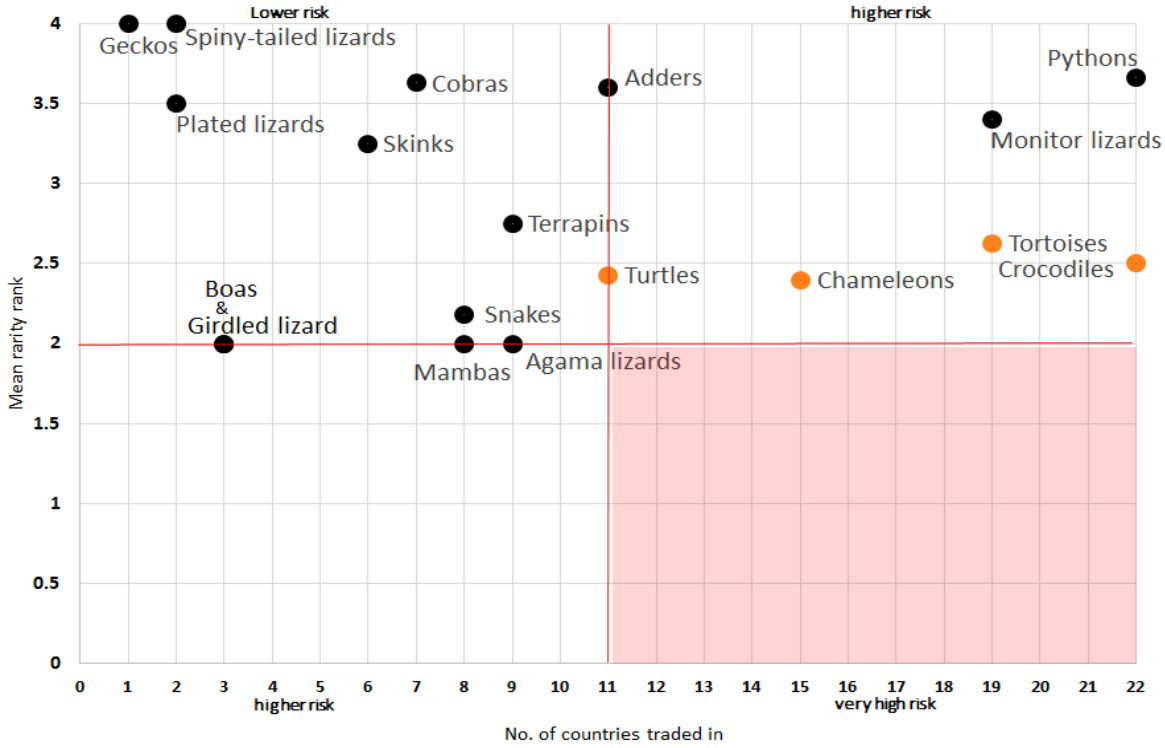

Figure 8. The mean rarity patterns of species recorded for therapeutic purposes and the total number of countries recorded in. The morphospecies indicated in orange contains at least a single Threatened species. The shaded quadrant represents the highest risks of population decline.

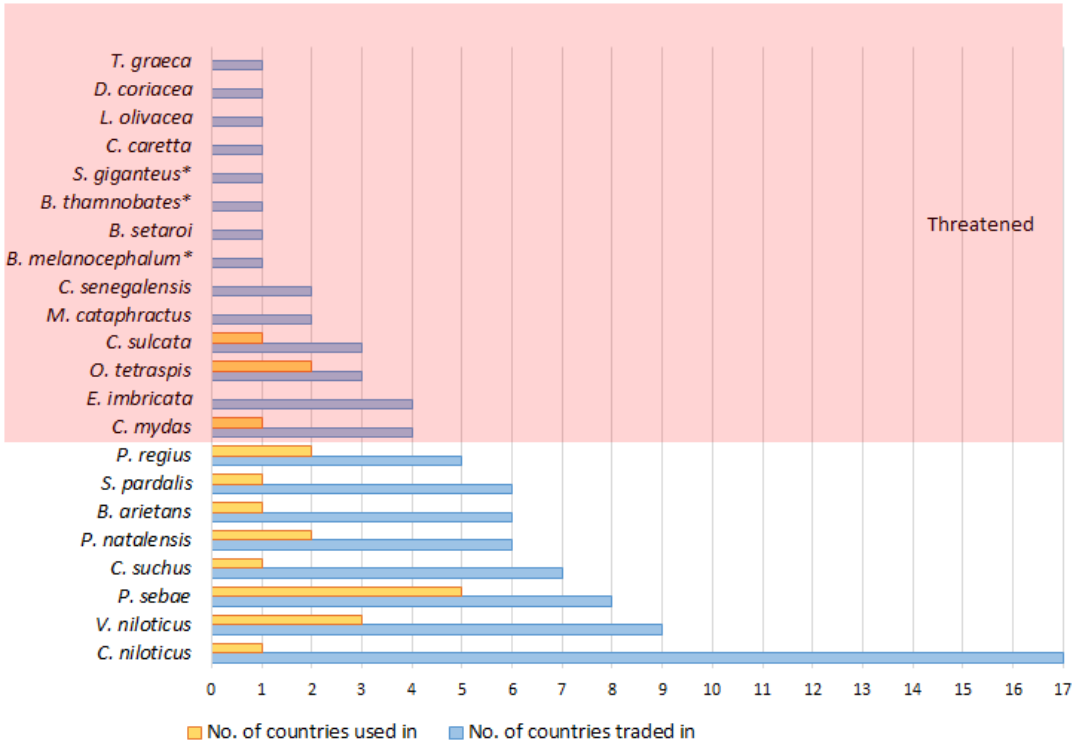

Figure 9. The most frequently recorded reptile species for therapeutic purpose, excluding unidentified taxa (e.g. '*Bitis* spp' or 'Mamba'). The species are arranged in terms of trade, from least traded to most traded. For conservation implications, the frequencies of all Threatened species (shaded in red) and top eight frequently recorded species (from *P.regius* to *C. niloticus*) are presented. The species marked with the asterisk (*) are endemic to South Africa and are Threatened locally.

4.4. Discussions and conclusion

Rarity in reptiles

Most of the therapeutic reptile species recorded tended to be abundant locally over large geographic ranges regardless of their habitat preferences (category A and B; n=51) (Table 10; Fig. 6). However, the two categories (A; B) from the rarity model had four species (*T. graeca*; *C. caretta; L. olivacea*; *Chelonia mydas*) categorised as Threatened on the IUCN Red List. In essence, all forms of commonness and rarity (ranging from A–H in the rarity model) were represented. Moreover, most of the Threatened reptile species (n=10) tend to have specific habitat preferences in category B (*C. caretta; L. olivacea*; *C. mydas*), category D (*M. cataphractus*; *E. imbricata*; *O. tetraspis*; *D. coriacea*; *C. sulcata*) and category F (*S. giganteus*; *C. senegalensis*) and those that are not Threatened have not been evaluated to (NE; n=61). Most of the evaluated species are of Least Concern (LC; n=26). Rarity categories in the model had the least number of species with sparse population sizes and relatively large geographic ranges (category C and G) including four species in category H (low geographic range; low

local population size and specific habitat preference) that could be in need of protection. All these least species recorded in the three rarity model categories (C; G and H) are not categorised as Threatened on the IUCN Red List.

Rarity in morphospecies

The study recorded 18 morphospecies groups from 101 species. The ranking procedure highlighted that cobras and snakes comprised most relatively common species, and chameleons and spiny lizards comprised most relatively rare species. Morphospecies groups (turtle, chameleons, boas, mambas and spiny lizards) with large proportions of rare species tend to exhibit intermediate underlying degrees of rareness, therefore general and immediate conservation efforts of such morphospecies groups is suggested. This is largely because the selection of therapeutic species is usually at morphospecies level than on species level. Conversely, morphospecies groups (geckos; pythons, cobras, adders, plated lizards, monitors, skinks, skinks, agamas, terrapins and tortoises) with large proportions of common species tend to be very common or intermediately common. Therefore, the conservation of each species should be distinct and not compromised by the morphospecies group they fall under.

Regions and Rarity

Most therapeutic reptiles were recorded in the tropic West Africa (Togo; Nigeria; Mali; n=56) and the temperate southern Africa (South Africa; n=45). There is a widespread belief that tropical systems have disproportionately large numbers of species with rareness tendencies (Gaston, 2012). Large proportions of species that tend to be common were recorded for therapeutic purposes locally in the countries than regionally.

On the IUCN Red List, reptiles are poorly represented. The figure stood at 35% of known species evaluated in 2011 (Böhm *et al*.2013) and in 2013, at least 19% of the world's reptiles were estimated to be Threatened (IUCN 2013). The Global Reptile Assessment (GRA) will address this shortcoming in future, however, the current overview is reliant on the current IUCN Red List of reptiles which according to Böhm *et al*., (2013) comprise geographical, taxonomic and Threatened species bias.

Rarity category H contained only four species from which two (*L. aurora*; *B. nemorale*) have been evaluated by IUCN. The latter species is endemic to South Africa whereas the former is

native to southern Africa (South Africa, Lesotho and Swaziland) and were better studied in Bates *et al*., (2014). The unevaluated species in category H are largely unknown; therefore require a thorough study to determine their conservation statuses. The patterns of rarity in reptile species can be used to guide further research and could assist in developing management strategies for rare species. Regardless of the efforts to focus on rare morphospecies groups, the dataset in this study suffer from paucity or a complete lack of data in some countries. Also, some of the studies, from which data was extracted from, are outdated, dating as far back as 1980s. It is likely that patterns of local trade or use of some therapeutic reptile species have changed. This is exacerbated by the unwelcoming traditional medicine traders leading to species being concealed (see e.g. Williams *et al*., 2016; Chaúque, 2010 and Alves *et al*., 2008). Given the limiting dataset and taxa not well studied in terms of distribution, taxonomy and extinction risk (Böhm *et al*., 2013) some important data that may have served to predict rarity of some species better could have been missed. Continued traditional medicine market surveys and analysis of therapeutic are needed to capture the trade trend. With more information on species data and documentation of new species following thorough market surveys, the rarity classification should become more complete and more accurate.

Despite the lack of trade and use information of therapeutic reptiles, Alves *et al*., (2015) recorded greater reptile diversity in Brazil and China of 284 reptiles from 202 genera and 57 families used in traditional medicine. However, their study was a global quantitative assessment from about 60 plus studies and included only two sources used in this study with data for Nigeria (Adeola, 1992) Morocco and Tunisia (Highfiled and Bayley, 2007). Similarly, Alves *et al*., (2015) recorded the largest number of snakes (123) used for traditional medicine and a large number of testudines included in the IUCN Red List. This indirectly support or mirrors reports of highly Threatened turtles in Böhm *et al*., (2013); and Tolley *et al*., (2016) for chameleons which were the second most Threatened in this study. These trade figures highlights the importance of reptiles for therapeutic purposes, even though their form of exploitation is an additional factor that puts pressure on their populations. Moreover, given the relatively small number of published studies, the subject of reptile trade may be underestimated.

The rarity assessments in this study could assist in developing management strategies for rare species. Future, focused and detailed research of markets could improve the classification of reptile rarities as well as the methodologies used in this study. Moreover, thorough research

accounts and more complete abundance data would likely change the placement of some species from their proposed rarity groups. The current study provides only a snapshot of rarity in reptiles.

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Supplementary Information A. The 101 species recorded for therapeutic purposes across 29 countries (excluding Angola which had no taxa identified to species) and their assigned rarity categories and ranks based on table 1. The species includes their global IUCN Red List status [a], SARCA[b] status and CITES[c] Appendix listing (I or II) [c]. The colours of the IUCN categories distinguish the conservation statuses (reproduced courtesy of IUCN 2016, http://www.iucnredlist.org/ about/introduction). The countries shaded in grey had non-market records only.

Order + **Family** + morphospecies	**Species**	**Common Name**	**(IUCN category) + CITES Appendix**	**Rarity Category + (rank)**	**Morphospecies mean rarity rank**	**Countries recorded in (max n=19) countries per species)**
Crocodylia **Crocodylidae** [Crocodiles]	*Crocodylus niloticus*	Nile crocodile	LC (1996) **I/II**	B (3)	2.5	Mozambique; Kenya; Tanzania; Ethiopia; Zambia; Malawi; Madagascar; Uganda; Sudan; Morocco; South Africa; Botswana; Namibia; Swaziland; Nigeria; Togo; Niger; Senegal
	Crocodylus suchus	West African crocodile	-	B(3)		Uganda; Mali; Benin; Nigeria; Togo; Niger; Senegal; Burkina Faso
	Mecistops cataphractus	African slender snouted crocodile	**CR (2014) I**	D(2)		Mali; Togo
	Osteolaemus tetraspis	African dwarf crocodile	VU (1996) **I**	D(2)		Cameroon; Benin; Mali; Togo; Burkina Faso
Squamata **Agamidae** [Agamas]	*Acanthocercus atricollis*	Southern tree agama	LC (2010)	A (4)	3.00	South Africa
	Agama agama	Red headed rock agama	LC (2013)	E (3)		Nigeria; Togo; Niger
	Agama impalearis	Bibron's agama	LC (2013)	F (2)		Morocco; Tunisia
	Agama mwanzae	Flat headed rock agama	LC (2014)	F (2)		Tanzania
	Trapelus mutabilis	Desert agama	-	D (2)		Morocco; Tunisia
[spiny tailed lizard]	*Uromastyx acanthinura*	North African spiny lizard	II	A (4)	4.00	Morocco; Tunisia
Boidae [boas]	*Calabaria reinhardtii*	African burrowing python	II	D (2)	2.00	Ghana
	Gongylophis muelleri	Sand boa	II	D (2)		Benin; Niger
Chamaeleonidae [chameleons]	*Bradypodion dracomontanum*	Drakensberg dwarf chameleon	NT (SARCA) II	F (2)	2.40	South Africa
	Bradypodion melanocephalum	Kwazulu dwarf chameleon	VU (SARCA) II	F (2)		South Africa
	Bradypodion nemorale	Qudeni dwarf chameleon	NT (1996) II NT (SARCA)	H (1)		South Africa
	Bradypodion setaroi	Setaro's dwarf chameleon	LC (2010) II LC (SARCA)	F (2)		South Africa
	Bradypodion thamnobates	Midlands dwarf chameleon	NT (1996) II VU (SARCA)	F (2)		South Africa

SI A (continued)

Order + **Family** + morphospecies	**Species**	**Common Name**	**(IUCN category) + CITES Appendix**	**Rarity Category + (rank)**	**Morphospecies mean rarity rank**	**Countries recorded in (max n=19) countries per species)**
	Chamaeleo africanus	African chameleon	LC (2014) II	B (3)		Mali; Niger
	Chamaeleo calcaricarens	Awash chameleon	LC (2014) II	G (2)		Somalia
	Chamaeleo chamaeleon	Mediterranean chameleon	LC (2012) II	F (2)		Morocco;Tunisia
	Chamaeleo dilepis dilepis	Common flap-neck chameleon	LC (2014) II	A (4)		Mozambique; Somalia; Zimbabwe; South Africa; Togo
	Chamaeleo gracilis	Craceful chameleon	LC (2014) II	B (3)		Togo; Ghana
	Chamaeleo senegalensis	Senegal chameleon	LC (2013) II	B (3)		Mali; Nigeria; Togo
Colubridae [snakes]	*Dasypeltis gansi*	Gans Egg eater	-	E (3)		Togo
	Dispholidus typus	Boomslang	-	A (4)		South Africa, Benin
	Grayia ornata	Ornate African water snake	-	B (3)		Gabon; Congo
	Grayia smithii	Smyth's water snake	-	B (3)		Benin; Mali
	Hapsidophrys smaragdina	Emerald snake	-	D (2)		Togo
	Philothamnus irregularis	Northern green bush snake	LC (2010)	A (4)		Togo
	Thelotornis capensis	Twig snake	LC (2010)	E (3)		Togo
	Thelotornis kirtlandii	Forest twig snake	-	B (3)		Togo
	Toxicodryas blandingii	Blanding's tree snake	-	B (3)		Togo
Lamprophiidae [snakes]	*Boaedon capensis*	Common house snake	-	A (4)		South Africa
	Boaedon fuliginosus	Brown house snake	-	A (4)		Togo
	Lamprophis aurora	Aurora house snake	LC (2010)	H (1)	3.18	South Africa
	Lycodonomorphus laevissimus	Dusky-bellied water snake	LC (SARCA)	F (2)		South Africa
	Lycodonomorphus rufulus	Brown water snake	LC (SARCA)	F (2)		South Africa
	Psammophis sibilans	Hissing sand snake	-	A (4)		Togo
	Psammophis mossambicus	Snake, olive whip snake	-	A (4)		South Africa
	Psammophis phillipsii	Snake, olive grass racer snake	-	A (4)		Togo; Burkina Faso
	Psammophylax rhombeatus	Rhombic skaapsteker snake	-	E (3)		South Africa
	Psammophylax tritaeniatus	Striped skaapsteker snake	LC (2010)	A (4)		South Africa
	Pseudaspis cana	Mole snake	-	A (4)		South Africa
	Rhamphiophis oxyrhynchus	Rufous snake	-	C (3)		Togo
Typhlopidae [snakes]	*Afrotyphlops bibronii*	Bibron's blind snake	LC (SARCA)	E (3)		South Africa
Cordylidae [Girdled lizards]	*Cordylus cordylus*	Cape girdled lizard	LC (Bates *et al.*, 2014)	F (2)		South Africa
	Cordylus jonesii	Limpopo girdled lizard	LC (SARCA) II	G (2)		South Africa

SI A (continued)

Order + **Family** + morphospecies	**Species**	**Common Name**	**(IUCN category) + CITES Appendix**	**Rarity Category + (rank)**	**Morphospecies mean rarity rank**	**Countries recorded in (max n=19) countries per species)**
	Cordylus vittifer	Transvaal girdled lizard	LC (SARCA II	F (2)		South Africa
	Smaug giganteus	Giant dragon lizard (Sungazer)	VU (1996) VU (SARCA) II	F (2)	2.00	South Africa
	Smaug warreni	Warren's dragon lizard	LC (SARCA) II	F (2)		South Africa; Mozambique
Elapidae [mambas]	*Dendroaspis angusticeps*	Green mamba	-	H (1)		Cameroon; South Africa
	Dendroaspis jamesonii	Jameson's mamba	-	B (3)		Benin
	Dendroaspis polylepis	Black mamba	LC (2010)	D (2)	2.00	Ethiopia; Zimbabwe; South Africa; Namibia
	Dendroaspis viridis	West African green mamba	LC (2010)	F (2)		Benin; Togo
[cobras]	*Hemachatus haemachatus*	Rinkhals	LC (2010)	E (3)		South Africa
	Naja annulifera	Snouted cobra	-	C (3)		South Africa
	Naja haje	Egyptian cobra	-	C (3)		Mali; Niger
	Naja katiensis	Mali cobra	LC (2010)	A (4)		Mali
	Naja melanoleuca	Forest cobra	-	A (4)	3.63	Mali; Togo
	Naja mossambica	Mozambique spitting cobra	-	A (4)		South Africa; Benin
	Naja nigricollis	Black-necked spitting cobra	-	A (4)		Benin; Mali; Nigeria; Togo; Niger; Ghana
	Naja nivea	Cape cobra	-	A (4)		South Africa
Gekkonidae [geckos]	*Hemidactylus mabouia*	Common tropical house gecko	-	A (4)	4.00	South Africa
Gerrhosauridae [plated lizards]	*Broadleysaurus major*	Rough-scaled plated Lizard	-	B (3)	3.50	Mozambique; South Africa
	Gerrhosaurus flavigularis	Yellow-throated plated Lizard	-	A (4)		South Africa
Pythonidae [pythons]	*Python natalensis*	Southern African python	II	A (4)		Mozambique; Zambia; Malawi; Zimbabwe; South Africa; Botswana; Namibia; Swaziland
	Python regius	Ball Python	LC (2010) II	B (3)	3.66	Cameroon; Benin; Mali; Nigeria; Togo; Niger; Ghana; Senegal
	Python sebae	Northern African python	II	A (4)		Cameroon; Kenya; Ethiopia; Uganda; Morocco; Benin; Mali; Nigeria; Togo; Niger; Ghana; Senegal; Burkina Faso

SI A (continued)

Order + **Family** + morphospecies	**Species**	**Common Name**	**(IUCN category) + CITES Appendix**	**Rarity Category + (rank)**	**Morphospecies mean rarity rank**	**Countries recorded in (max n=19) countries per species)**
Scincidae [skinks]	*Acontias plumbeus*	Giant legless skink	LC (2010)	F (2)	3.25	South Africa
	Eumeces algeriensis	Algerian-orange tailed skink	LC (2009)	E (3)		Morocco; Tunisia
	Trachylepis perrotetii	Fire-sided skink	-	A (4)		Togo
	Trachylepis striata	African striped skink	-	A (4)		South Africa
Varanidae [monitor lizards]	*Varanus albigularis*	Southern rock monitor	II	A (4)	3.40	Zimbabwe; South Africa
	Varanus exanthematicus	Savannah monitor	LC (2010) II	A (4)		Mali; Togo; Niger; Ghana; Burkina Faso
	Varanus griseus	Desert monitor	II	A (4)		Morocco; Tunisia; Mali
	Varanus niloticus	Nile monitor	I	B (3)		Cameroon; Mozambique; Kenya; Ethiopia; Malawi; Zimbabwe; South Africa; Mali; Nigeria; Togo; Niger; Senegal
	Varanus ornatus	Ornate monitor	II	F (2)		Togo
Viperidae [adders]	*Bitis arietans*	Puff adder	-	A (4)	3.60	Zambia; South Africa; Benin; Mali; Nigeria; Togo; Niger
	Bitis gabonica	Gaboon adder	-	B (3)		Cameroon; Mozambique; Nigeria
	Bitis nasicornis	Rhinoceros adder	-	B (3)		Cameroon; Mali; Togo; Ghana
	Bitis rhinoceros	West African adder gaboon	LC (2013)	F (2)		Mali; Togo; Ghana
	Causus rhombeatus	Night adder	-	A (4)		Nigeria
Testudine	*Caretta caretta*	Loggerhead turtle	VU (2015) I	B (3)	2.43	South Africa
Cheloniidae [turtles]	*Chelonia mydas*	Green turtle	EN (2004) I	B (3)		Mozambique; Kenya; Somalia; Eritrea; Togo
	Eretmochelys imbricata	Hawksbill turtle	CR (2008) I	D (2)		Mozambique; Somalia; South Africa; Togo
	Lepidochelys olivacea	Olive ridley turtle	VU (2009) I	B (3)		Togo
Dermochelyidae [turtles]	*Dermochelys coriacea*	Leatherback turtle	VU (2013) I	D (2)		Togo
Trionychidae [turtles]	*Cyclanorbis senegalensis*	Senegal flapshell turtle	VU (2016) II	F (2)		Mali; Togo
	Trionyx triunguis	Nile-softshelled turtle	II	D (2)		Mali; Togo
Pelomedusidae [terrapins]	*Pelomedusa subrufa*	African helmeted terrapin	-	B (3)	2.75	Togo; Niger; Burkina Faso
	Pelusios castaneus	West African mud terrapin	-	B (3)		Togo; Burkina Faso
	Pelusios niger	West African black forest turtle	-	F (2)		Togo
	Pelusios sinuatus	Serrated hinged terrapin	-	B (3)		South Africa

SI A (continued)

Order + **Family** + morphospecies	**Species**	**Common Name**	**(IUCN category) + CITES Appendix**	**Rarity Category + (rank)**	**Morphospecies mean rarity rank**	**Countries recorded in (max n=19) countries per species)**
Testudinidae [tortoises]	*Centrochelys sulcata*	African spurred tortoise	VU (1996) II	D (2)	2.63	Mali; Togo; Niger; Burkina Faso
	Chersina angulata	Angulate tortoise	LC (SARCA) II	E (3)		South Africa
	Kinixys zombensis	Bell's hinged tortoise	-	D (2)		Mozambique; South Africa; Nigeria; Togo
	Kinixys erosa	Forest hinged tortoise	DD II	D (2)		Nigeria; Togo
	Kinixys homeana	Home's hinged tortoise	II	H (1)		Nigeria; Togo
	Kinixys spekii	Speke's hinged tortoise	II	C (3)		South Africa
	Stigmochelys pardalis	Leopard tortoise	LC (2015) II	A (4)		Kenya; Somalia; Ethiopia; Malawi; South Africa; Namibia; Togo
	Testudo graeca	Spur-thighed tortoise	VU (1996) II	A (4)		Morocco

[a] Red List status: CR=Critically Endangered; EN=Endangered; VU=Vulnerable; NT=Near Threatened; LC=Least Concern; DD=Data Deficient; NE=Not Evaluated

[b] CITES listing: Appendix **I** includes species Threatened with extinction and their trade is permitted only in exceptional circumstances. Appendix **II** includes species that are not necessarily Threatened with extinction, but in which their trade must be controlled to avoid utilization incompatible with their survival; The CITES Appendix status of *Crocodylus niloticus* is **I** or **II** depending on the region it occurs in

[c] SARCA status in Bates *et al.* (2014) for species endemic or near endemic to South Africa.

Supplementary Information B. The 101 species recorded for therapeutic purposes across five African regions and their assigned rarity categories and ranks based on table 1. The species includes their global IUCN Red List status [a], SARCA[b] status and CITES Appendix listing (I or II) [c]. The colours of the IUCN categories distinguish the conservation statuses (reproduced courtesy of IUCN 2016, http://www.iucnredlist.org/ about/introduction). The countries shaded in grey had non-market records only

Region	Order + Family +	Species	Common Name	(IUCN category) + CITES Appendix	Rarity Category + (rank)	Mean Rarity Rank	Countries recorded in (max n=8)
Central Africa	**Crocodylia** **Crocodylidae**	*Osteolaemus tetraspis*	African dwarf crocodile	VU (1996) **I**	D(2)	2.75	Cameroon
	Squamata **Colubridae**	*Grayia ornata*	Ornate African water snake	-	B (3)		Gabon; Congo
	Elapidae	*Dendroaspis angusticeps*	Green mamba	-	H (1)		Cameroon
	Pythonidae	*Python regius*	Ball Python	LC (2010) II	B (3)		Cameroon
		Python sebae	Northern African python	II	A (4)		Cameroon
	Viperidae	*Bitis gabonica*	Gaboon adder	-	B (3)		Cameroon
		Bitis nasicornis	Rhinoceros adder	-	B (3)		Cameroon
	Varanidae	*Varanus niloticus*	Nile monitor	I	B (3)		Cameroon
southern Africa	**Crocodylia** **Crocodylidae**	*Crocodylus niloticus*	Nile crocodile	LC (1996) **I/II**	B (3)	2.88	South Africa; Botswana; Namibia; Swaziland
	Squamata **Agamidae**	*Acanthocercus atricollis*	Southern tree agama	LC (2010)	A (4)		South Africa
	Chamaeleonidae	*Bradypodion dracomontanum*	Drakensberg dwarf chameleon	NT (SARCA) II	F (2)		South Africa
		Bradypodion melanocephalum	Chameleon, KwaZulu dwarf	VU (SARCA) II	F (2)		South Africa
		Bradypodion nemorale	Qudeni dwarf chameleon	NT (1996) II NT (SARCA)	H (1)		South Africa
		Bradypodion setaroi	Setaro's dwarf chameleon	LC (2010) II LC (SARCA)	F (2)		South Africa
		Bradypodion thamnobates	Midlands dwarf chameleon	NT (1996) II VU (SARCA)	F (2)		South Africa
		Chamaeleo dilepis	Common flap-neck chameleon	LC (2014) II	A (4)		South Africa
	Colubridae	*Dispholidus typus*	Boomslang	-	A (4)		South Africa

SI B (continued)

Region	Order + Family +	Species	Common Name	(IUCN category) + CITES Appendix	Rarity Category + (rank)	Mean Rarity Rank	Countries recorded in (max n=8)
	Cordylidae	*Cordylus cordylus*	Cape girdled lizard	LC (Bates *et al.*, 2014)	F (2)		South Africa
		Cordylus jonesii	Limpopo girdled lizard	LC (SARCA) II	G (2)		South Africa
		Cordylus vittifer	Transvaal girdled lizard	LC (SARCA II	F (2)		South Africa
		Smaug giganteus	Giant dragon lizard (sungazer)	VU (1996)	F(2)		South Africa
				VU (SARCA) II			
		Smaug warreni warreni	Warren's dragon lizard	LC (SARCA) II	F (2)		South Africa
	Elapidae	*Dendroaspis angusticeps*	Green mamba	-	H (1)		South Africa
		Dendroaspis polylepis	Black mamba	LC (2010)	D (2)		South Africa; Namibia
		Hemachatus haemachatus	Rinkhals	LC (2010)	E (3)		South Africa
		Naja annulifera	Snouted cobra	-	C (3)		South Africa
		Naja mossambica	Mozambique spitting cobra	-	A (4)		South Africa
		Naja nivea	Cape cobra	-	A (4)		South Africa
	Gekkonidae	*Hemidactylus mabouia*	Common tropical house gecko	-	A (4)		South Africa
	Gerrhosauridae	*Broadleysaurus major*	Rough-scaled plated Lizard	-	B (3)		South Africa
		Gerrhosaurus flavigularis	Yellow-throated plated Lizard	-	A (4)		South Africa
	Lamprophiidae	*Boaedon capensis*	Common house snake	-	A (4)		South Africa
		Lamprophis aurora	Brown house snake	-	A (4)		South Africa
		Lycodonomorphus laevissimus	Water snake, Dusky-bellied				South Africa
		Lycodonomorphus rufulus	Dusky-bellied water snake	LC (SARCA)	F (2)		South Africa
		Psammophis mossambicus	Brown water snake	LC (SARCA)	F (2)		South Africa
		Psammophylax rhombeatus	Rhombic skaapsteker snake	-	E (3)		South Africa
		Pseudaspis cana	Mole snake	-	A (4)		South Africa
	Pythonidae	*Python natalensis*	Southern African python	II	A (4)		South Africa; Botswana; Namibia; Swaziland
	Scincidae	*Acontias plumbeus*	Giant legless skink	LC (2010)	F (2)		South Africa
		Trachylepis striata	African striped skink	-	A (4)		South Africa
	Typhlopidae	*Afrotyphlops bibronii*	Bibron's blind snake	LC (SARCA)	E (3)		South Africa
	Varanidae	*Varanus albigularis*	Southern rock monitor	II	A (4)		South Africa
		Varanus niloticus	Nile monitor	I	B (3)		South Africa
	Viperidae	*Bitis arietans*	Night adder	-	A (4)		South Africa

SI B (continued)

Region	Order + Family +	Species	Common Name	(IUCN category) + CITES Appendix	Rarity Category + (rank)	Mean Rarity Rank	Countries recorded in (max n=8)
West Africa	**Testudine** **Cheloniidae**	*Caretta caretta*	Loggerhead turtle	VU (2015) I	B (3)		South Africa
		Eretmochelys imbricata	Hawksbill turtle	CR (2008) I	D (2)		South Africa
	Pelomedusidae	*Pelusios sinuatus*	Serrated hinged terrapin	-	B (3)		South Africa
	Testudinidae	*Chersina angulata*	Angulate tortoise	LC (SARCA) II	E (3)		South Africa
		Kinixys zombensis	Bell's hinged tortoise	-	D (2)		South Africa
		Kinixys spekii	Speke's hinged tortoise	II	C (3)		South Africa
		Stigmochelys pardalis	Leopard tortoise	LC (2015) II	A (4)		South Africa; Namibia
	Crocodylia **Crocodylidae**	*Crocodylus niloticus*	Nile crocodile	LC (1996) **I/II**	B (3)	2.98	Nigeria; Togo; Niger; Senegal
		Crocodylus suchus	West African crocodile	-	B(3)		Benin; Mali; Nigeria; Togo; Niger; Senegal; Burkina Faso
		Mecistops cataphractus	African slender snouted crocodile	**CR (2014) I**	D(2)		Mali; Togo
		Osteolaemus tetraspis	African dwarf crocodile	VU (1996) **I**	D(2)		Benin; Mali; Togo; Burkina Faso
	Squamata **Agamidae**	*Agama agama*	Red headed rock agama	LC (2013)	E (3)		Nigeria; Togo; Niger
	Boidae	*Calabaria reinhardtii*	African burrowing python	II	D (2)		Ghana
		Gongylophis muelleri	Sand boa	II	D (2)		Mali; Niger
	Chamaeleonidae	*Chamaeleo africanus*	African chameleon	LC (2014) II	B (3)		Mali; Niger
		Chamaeleo dilepis	Common flap-neck chameleon	LC (2014) II	A (4)		Togo
		Chamaeleo gracilis	Graceful chameleon	LC (2014) II	B (3)		Togo; Ghana
		Chamaeleo senegalensis	Senegal chameleon	LC (2013) II	B (3)		Mali; Nigeria; Togo
	Colubridae	*Dasypeltis gansi*	Gans egg eater	-	E (3)		Togo
		Dispholidus typus	Boomslang	-	A (4)		Benin
		Grayia smithii	Smyth's water snake	-	B (3)		Benin; Mali
		Hapsidophrys smaragdina	Emerald snake	-	D (2)		Togo
		Philothamnus irregularis	Northern green bush snake	LC (2010)	A (4)		Togo
		Thelotornis capensis	Twig snake	LC (2010)	E (3)		Togo
		Thelotornis kirtlandii	Forest twig snake	-	B (3)		Togo
		Toxicodryas blandingii	Blanding's tree snake	-	B (3)		Togo

SI B (continued)

Region	Order + Family +	Species	Common Name	(IUCN category) + CITES Appendix	Rarity Category + (rank)	Mean Rarity Rank	Countries recorded in (max n=8)
	Elapidae	*Dendroaspis jamesonii*	Jameson's mamba	-	B (3)		Benin
		Dendroaspis viridis	West African green mamba	LC (2010)	F (2)		Benin; Togo
		Naja haje	Egyptian cobra	-	C (3)		Mali; Niger
		Naja katiensis	Mali cobra	LC (2010)	A (4)		Mali
		Naja melanoleuca	Forest cobra	-	A (4)		Mali; Togo
		Naja mossambica	Mozambique spitting cobra	-	A (4)		Benin
		Naja nigricollis	Black-necked spitting cobra	-	A (4)		Benin; Mali; Nigeria; Togo; Niger; Ghana
	Lamprophiidae	*Boaedon fuliginosus*	Brown house snake	-	A (4)		Togo
		Psammophis sibilans	Hissing sand snake	-	A (4)		Togo
		Psammophis phillipsii	Olive grass racer snake	-	A (4)		Togo; Burkina Faso
		Rhamphiophis oxyrhynchus	Rufous snake	-	C (3)		Togo
	Pythonidae	*Python regius*	Ball python	LC (2010) II	B (3)		Benin; Mali; Togo; Niger; Ghana; Senegal
		Python sebae	Northern African python	II	A (4)		Benin; Mali; Nigeria; Togo; Niger; Ghana; Senegal; Burkina Faso
	Scincidae	*Trachylepis perrotetii*	Fire-sided skink	-	A (4)		Togo
	Varanidae	*Varanus exanthematicus*	Savannah monitor	LC (2010) II	A (4)		Mali; Togo; Niger; Ghana; Burkina Faso
		Varanus griseus	Desert monitor	II	A (4)		Mali
		Varanus niloticus	Nile monitor	I	B (3)		Mali; Nigeria; Togo; Niger; Senegal
		Varanus ornatus	Ornate monitor	II	F (2)		Togo
	Viperidae	*Bitis arietans*	Puff adder	-	A (4)		Benin; Mali; Nigeria; Togo; Niger
		Bitis gabonica	Gaboon adder	-	B (3)		Nigeria
		Bitis nasicornis	Rhinoceros adder	-	B (3)		Mali; Togo; Ghana
		Bitis rhinoceros	West African gaboon adder	LC (2013)	F (2)		Mali; Togo; Ghana
		Causus rhombeatus	Night adder	-	A (4)		Nigeria
	Testudine **Cheloniidae**	*Chelonia mydas*	Green turtle	EN (2004) I	B (3)		Togo

SI B (continued)

Region	Order + Family +	Species	Common Name	(IUCN category) + CITES Appendix	Rarity Category + (rank)	Mean Rarity Rank	Countries recorded in (max n=8)
	Chelonidae	*Eretmochelys imbricata*	Hawksbill turtle	CR (2008) I	D (2)		Togo
		Lepidochelys olivacea	Olive ridley turtle	VU (2009) I	B (3)		Togo
	Dermochelyidae	*Dermochelys coriacea*	Leatherback turtle	VU (2013) I	D (2)		Togo
	Trionychidae	*Cyclanorbis senegalensis*	Senegal flap shell turtle	VU (2016) II	F (2)		Mali; Togo
		Trionyx triunguis	Nile soft-shelled turtle	II	D (2)		Mali; Togo
	Pelomedusidae	*Pelomedusa subrufa*	African helmeted terrapin	-	B (3)		Togo; Niger; Burkina Faso
		Pelusios castaneus	West African mud terrapin	-	B (3)		Togo; Burkina Faso
		Pelusios niger	West African black forest turtle	-	F (2)		Togo
	Testudinidae	*Centrochelys sulcata*	African spurred tortoise	VU (1996) II	D (2)		Mali; Togo; Niger; Burkina Faso
		Kinixys zombensis	Bell's hinged tortoise	-	D (2)		Nigeria; Togo
		Kinixys erosa	Forest hinged tortoise	DD II	D (2)		Nigeria; Togo
		Kinixys homeana	Home's hinged tortoise	II	H (1)		Nigeria; Togo
		Stigmochelys pardalis	Leopard tortoise	LC (2015) II	A (4)		Togo
East Africa	**Crocodylia** **Crocodylidae**	*Crocodylus niloticus*	Nile crocodile	LC (1996) **I/II**	B (3)	3.00	Mozambique; Kenya; Tanzania; Ethiopia; Zambia; Malawi; Madagascar; Uganda
		Crocodylus suchus	West African crocodile	-	B(3)		Uganda
	Squamata **Agamidae**	*Agama mwanzae*	Flat headed rock agama	LC (2014)	F (2)		Tanzania
	Chamaeleonidae	*Chamaeleo calcaricarens*	Awash chameleon	LC (2014) II	G (2)		Somalia
		Chamaeleo dilepis dilepis	Common flap-neck chameleon	LC (2014) II	A (4)		Mozambique; Somalia; Zimbabwe
	Cordylidae	*Smaug warreni warreni*	Warren's dragon lizard	LC (SARCA) II	F (2)		Mozambique
	Elapidae	*Dendroaspis polylepis*	Black mamba	LC (2010)	D (2)		Ethiopia; Zimbabwe
	Gerrhosauridae	*Broadleysaurus major*	Rough-scaled plated lizard	-	B (3)		Mozambique
	Pythonidae	*Python natalensis*	Rough-scaled plated Lizard	-	B (3)		Mozambique; Zambia; Malawi; Zimbabwe
		Python regius	Ball Python	LC (2010) II	B (3)		Tanzania
		Python sebae	Northern African python	II	A (4)		Kenya; Ethiopia; Uganda
	Varanidae	*Varanus albigularis*	Southern rock monitor	II	A (4)		Zimbabwe
		Varanus niloticus	Nile monitor	I	B (3)		Mozambique; Kenya; Ethiopia; Malawi; Zimbabwe

SI B (continued)

Region	Order + Family +	Species	Common Name	(IUCN category) + CITES Appendix	Rarity Category + (rank)	Mean Rarity Rank	Countries recorded in (max n=8)
	Viperidae	*Bitis arietans*	Puff adder	-	A (4)		Zambia
		Bitis gabonica	Gaboon adder	-	B (3)		Mozambique
	Cheloniidae	*Chelonia mydas*	Green turtle	EN (2004) I	B (3)		Mozambique; Kenya; Somalia; Eritrea
		Eretmochelys imbricata	Hawksbill turtle	CR (2008) I	D (2)		Mozambique; Somalia
	Testudinidae	*Kinixys zombensis*	Bell's hinged tortoise	-	D (2)		Mozambique
		Stigmochelys pardalis	Leopard tortoise	LC (2015) II	A (4)		Kenya; Somalia; Ethiopia; Malawi
North Africa	**Crocodylia Crocodylidae**	*Crocodylus niloticus*	Nile crocodile	LC (1996) **I/II**	B (3)	3.11	Sudan; Morocco
	Squamata Agamidae	*Agama impalearis*	Bibron's agama	LC (2013)	F (2)		Morocco; Tunisia
		Trapelus mutabilis	Desert agama	-	D (2)		Morocco; Tunisia
		Uromastyx acanthinura	North African spiny lizard	II	A (4)		Morocco; Tunisia
	Chamaeleonidae	*Chamaeleo chamaeleon*	Mediterranean chameleon	LC (2012) II	F (2)		Morocco; Tunisia
	Pythonidae	*Python sebae*	Northern African python	II	A (4)		Morocco
	Scincidae	*Eumeces algeriensis*	Algerian-orange tailed skink	LC (2009)	E (3)		Morocco; Tunisia
	Varanidae	*Varanus griseus*	Desert monitor	II	A (4)		Morocco; Tunisia
	Testudinidae	*Testudo graeca*	Spur-thighed tortoise	VU (1996) II	A (4)		Morocco

[a] Red List status: CR=Critically Endangered; EN=Endangered; VU=Vulnerable; NT=Near Threatened; LC=Least Concern; DD=Data Deficient; NE=Not Evaluated

[b] CITES listing: Appendix **I** includes species Threatened with extinction and their trade is permitted only in exceptional circumstances. Appendix **II** includes species that are not necessarily Threatened with extinction, but in which their trade must be controlled to avoid utilization incompatible with their survival; The CITES Appendix status of *Crocodylus niloticus* is **I** or **II** depending on the region it occurs in

[c] SARCA status in Bates *et al.* (2014) for species endemic or near endemic to South Africa.

Supplementary Information C. An inventory of reptile taxa not identified to species recorded for therapeutic purposes in 30 countries. The countries shaded in grey had non-market records only and the ones in **bold** are exclusive to the specified genus.

Order + **Family**	**Species**	**Morphospecies**	**Countries recorded in (max n=11)**
Crocodylia **Crocodylidae**	*Crocodylus sp.*	crocodile	Nigeria; Togo
Squamata **Agamidae**	*Agama sp.*	agama	South Africa; Benin; Nigeria; Togo; Ghana
	Uromastyx sp.	spiny lizard	Morocco
Chamaeleonidae	*Chamaeleo sp*	chameleon	South Africa; **Namibia; Benin**; Mali; Nigeria; Togo; **Burkina Faso**
	Unknown species	chameleon	Angola, South Africa; **Benin**
Colubridae	*Gonionotophis sp.*	file snake	Togo
	Meizodon sp.	African smooth snake	Togo
	Philothamnus sp.	green snake	Benin; South Africa
Cordylidae	*Cordylus sp.*	girdled lizard	South Africa; Botswana
Elapidae	*Dendroaspis sp.*	mamba	South Africa; Nigeria
	Naja sp.	cobra	**Tanzania**; South Africa; Benin; Nigeria; Togo
Lamprophiidae	*Amblyodipsas sp.*	lizard	South Africa
	Psammophis sp.	purple-glossed snake	South Africa; Togo
Pythonidae	*Python sp.*	sand snake	Uganda; Mali
Scincidae	*Chalcides spp.*	skink	Morocco; Tunisia
	Trachylepis sp.	skink	**Ethiopia; Ghana**
	Unidentified skink	skink	Morocco; Tunisia
Varanidae	*Varanus sp.*	monitor	Kenya; Malawi; **Uganda**; South Africa; **Botswana; Benin;** Mali; Burkina Faso
Viperidae	*Bitis sp.*	adder	South Africa; Togo
	Unidentified adder	adder	**Angola**; Benin
Testudine **Cheloniidae**	Unidentified	turtle	Mozambique; Kenya; Somalia; **Tanzania**; **Eritrea; Malawi**; **Madagascar; Morocco**; South Africa; Togo
Pelomedusidae	*Pelomedusa sp.*	terrapin	**Mali; Nigeria; Ghana**
	Pelusios sp.	terrapin	Togo; **Ghana**; Burkina Faso
	Unidentified	terrapin	**Morocco; Tunisia**; South Africa; Togo

SI C (continued)

Order + **Family**	**Species**	**Morphospecies**	**Countries recorded in (max n=18)**
Testudinidae	*Centrochelys sp.*	tortoise	**Ghana**
	Homopus sp.	padloper	**South Africa**
	Kinixys sp.	tortoise	**Cameroon;** Mozambique; South Africa; **Benin; Mali**; Nigeria
	Unidentified tortoise	tortoise	Tanzania; Malawi; Zimbabwe; Morocco; Tunisia; South Africa; Nigeria; Togo
	Unidentified turtle	turtle	**Morocco**; South Africa; Togo
Unknown **unknown family**	Unidentified lizard	lizard	Togo; **Uganda**; Morocco; Tunisia; South Africa; Togo
	Unidentified snake	Snake	Namibia

Supplementary Information D. The percentage of species similarity across 29 countries (excludes Angola which had two reptiles identified to genus). The percentage similarities are given from highest to lowest in a descending order. The grey shaded rows highlights comparisons of different regions.

Region A	Region B	Country A	Country B	Sorensen similarity %	No. species in country A	No. species in country B	No. Shared species
South	South	Botswana	Swaziland	100%	2	2	2
Central	Central	Gabon	Congo	100%	1	1	1
West	West	Madagascar	Sudan	100%	1	1	1
North	North	Morocco	Tunisia	80%	6	9	6
East	East	Kenya	Ethiopia	80%	4	5	5
W	S	Zambia	Botswana	80%	2	3	2
W	S	Zambia	Swaziland	80%	2	3	2
E	S	Malawi	Namibia	75%	3	4	4
W	W	Uganda	Senegal	75%	3	3	5
E	E	Ethiopia	Malawi	67%	3	5	4
E	S	Ethiopia	Namibia	67%	3	5	4
E	E	Kenya	Malawi	67%	3	5	4
S	S	Namibia	Swaziland	67%	2	4	2
W	S	Malawi	Botswana	67%	2	4	2
W	S	Malawi	Swaziland	67%	2	4	2
S	S	Botswana	Namibia	67%	2	2	4
N	S	Sudan	Botswana	67%	1	1	2
N	S	Sudan	Swaziland	67%	1	1	2
W	S	Madagascar	Botswana	67%	1	1	2
W	S	Madagascar	Swaziland	67%	1	1	2
W	W	Mali	Niger	61%	11	22	14
E	W	Ethiopia	Senegal	60%	3	5	5
E	W	Kenya	Senegal	60%	3	5	5
W	E	Zambia	Malawi	57%	2	3	4
W	S	Zambia	Namibia	57%	2	3	4
W	W	Niger	Senegal	53%	5	14	5
W	W	Nigeria	Niger	52%	7	13	14
C	W	Cameroon	Senegal	50%	3	7	5
W	E	Ethiopia	Uganda	50%	2	5	3
W	E	Kenya	Uganda	50%	2	5	3
W	W	Tanzania	Senegal	50%	2	3	5
W	E	Tanzania	Madagascar	50%	1	3	1
W	N	Tanzania	Sudan	50%	1	3	1
W	N	Uganda	Sudan	50%	1	3	1

SI D. (Continued)

Region A	Region B	Country A	Country B	Sorensen similarity %	No. species in country A	No. species in country B	No. Shared species
W	E	Zambia	Madagascar	50%	1	3	1
W	N	Zambia	Sudan	50%	1	3	1
W	E	Madagascar	Uganda	50%	1	1	3
W	W	Mali	Togo	49%	16	22	44
W	W	Niger	Burkina Faso	46%	5	14	8
W	W	Nigeria	Senegal	44%	4	13	5
E	S	Kenya	Namibia	44%	2	5	4
E	S	Zimbabwe	Namibia	44%	2	5	4
E	W	Malawi	Senegal	44%	2	4	5
E	E	Malawi	Zimbabwe	44%	2	4	5
E	E	Mozambique	Malawi	43%	3	10	4
W	W	Benin	Mali	42%	7	11	22
W	W	Mali	Ghana	40%	6	22	8
W	W	Benin	Niger	40%	5	11	14
E	E	Mozambique	Kenya	40%	3	10	5
E	E	Mozambique	Somalia	40%	3	10	5
E	E	Mozambique	Zimbabwe	40%	3	10	5
C	W	Cameroon	Ghana	40%	3	7	8
E	E	Ethiopia	Zimbabwe	40%	2	5	5
E	E	Kenya	Somalia	40%	2	5	5
W	E	Malawi	Madagascar	40%	1	4	1
W	N	Malawi	Sudan	40%	1	4	1
W	S	Tanzania	Botswana	40%	1	3	2
W	S	Tanzania	Swaziland	40%	1	3	2
W	S	Uganda	Botswana	40%	1	3	2
W	S	Uganda	Swaziland	40%	1	3	2
N	S	Sudan	Namibia	40%	1	1	4
W	S	Madagascar	Namibia	40%	1	1	4
W	W	Nigeria	Togo	39%	11	13	44
W	W	Togo	Niger	38%	11	44	14
W	W	Benin	Senegal	38%	3	11	5
W	W	Uganda	Nigeria	38%	3	3	13
W	W	Niger	Ghana	36%	4	14	8
W	W	Uganda	Burkina Faso	36%	2	3	8
W	W	Uganda	Niger	35%	3	3	14
E	W	Mozambique	Nigeria	35%	4	10	13

SI D. (Continued)

Region A	Region B	Country A	Country B	Sorensen similarity %	No. species in country A	No. species in country B	No. Shared species
C	W	Cameroon	Mali	35%	5	7	22
W	W	Mali	Nigeria	34%	6	22	13
W	W	Mali	Burkina Faso	33%	5	22	8
W	W	Benin	Nigeria	33%	4	11	13
C	W	Cameroon	Benin	33%	3	7	11
E	W	Ethiopia	Nigeria	33%	3	5	13
E	W	Kenya	Nigeria	33%	3	5	13
W	S	Mozambique	Botswana	33%	2	10	2
W	S	Mozambique	Swaziland	33%	2	10	2
C	E	Cameroon	Ethiopia	33%	2	7	5
C	E	Cameroon	Kenya	33%	2	7	5
W	N	Uganda	Morocco	33%	2	3	9
W	E	Ethiopia	Madagascar	33%	1	5	1
W	N	Ethiopia	Sudan	33%	1	5	1
W	E	Kenya	Eritrea	33%	1	5	1
W	E	Kenya	Madagascar	33%	1	5	1
W	N	Kenya	Sudan	33%	1	5	1
W	E	Somalia	Eritrea	33%	1	5	1
W	E	Tanzania	Uganda	33%	1	3	3
W	E	Tanzania	Zambia	33%	1	3	3
W	E	Zambia	Uganda	33%	1	3	3
N	W	Sudan	Senegal	33%	1	1	5
W	W	Madagascar	Senegal	33%	1	1	5
W	W	Benin	Burkina Faso	32%	3	11	8
W	W	Benin	Ghana	32%	3	11	8
E	W	Ethiopia	Niger	32%	3	5	14
E	W	Kenya	Niger	32%	3	5	14
W	W	Togo	Burkina Faso	31%	8	44	8
W	E	Mozambique	Zambia	31%	2	10	3
W	W	Ghana	Senegal	31%	2	8	5
W	W	Senegal	Burkina Faso	31%	2	5	8
C	W	Cameroon	Nigeria	30%	3	7	13
W	W	Mali	Senegal	30%	4	22	5
E	S	Mozambique	South Africa	29%	8	10	45
C	W	Cameroon	Niger	29%	3	7	14
E	S	Mozambique	Namibia	29%	2	10	4

SI D. (Continued)

Region A	Region B	Country A	Country B	Sorensen similarity %	No. species in country A	No. species in country B	No. Shared species
N	W	Morocco	Senegal	29%	2	9	5
E	N	Ethiopia	Morocco	29%	2	5	9
E	N	Kenya	Morocco	29%	2	5	9
W	W	Uganda	Benin	29%	2	3	11
W	S	Ethiopia	Botswana	29%	1	5	2
W	S	Ethiopia	Swaziland	29%	1	5	2
W	S	Kenya	Botswana	29%	1	5	2
W	S	Kenya	Swaziland	29%	1	5	2
W	S	Zimbabwe	Botswana	29%	1	5	2
W	S	Zimbabwe	Swaziland	29%	1	5	2
W	E	Malawi	Uganda	29%	1	4	3
W	E	Tanzania	Malawi	29%	1	3	4
W	S	Tanzania	Namibia	29%	1	3	4
W	S	Uganda	Namibia	29%	1	3	4
S	W	Botswana	Senegal	29%	1	2	5
S	W	Swaziland	Senegal	29%	1	2	5
W	W	Togo	Ghana	27%	7	44	8
E	E	Mozambique	Ethiopia	27%	2	10	5
E	W	Mozambique	Senegal	27%	2	10	5
C	W	Cameroon	Burkina Faso	27%	2	7	8
W	W	Benin	Togo	26%	7	11	44
W	W	Ghana	Burkina Faso	25%	2	8	8
W	W	Zambia	Nigeria	25%	2	3	13
W	E	Ethiopia	Zambia	25%	1	5	3
W	E	Kenya	Tanzania	25%	1	5	3
W	E	Kenya	Zambia	25%	1	5	3
W	E	Tanzania	Ethiopia	25%	1	3	5
W	W	Zambia	Senegal	25%	1	3	5
W	E	Zambia	Zimbabwe	25%	1	3	5
C	E	Cameroon	Mozambique	24%	2	7	10
E	W	Malawi	Nigeria	24%	2	4	13
W	W	Tanzania	Niger	24%	2	3	14
W	W	Zambia	Niger	24%	2	3	14
E	W	Mozambique	Togo	22%	6	10	44
E	W	Malawi	Niger	22%	2	4	14
E	E	Somalia	Malawi	22%	1	5	4

SI D. (Continued)

Region A	Region B	Country A	Country B	Sorensen similarity %	No. species in country A	No. species in country B	No. Shared species
E	S	Somalia	Namibia	22%	1	5	4
S	W	Namibia	Senegal	22%	1	4	5
W	W	Togo	Senegal	20%	5	44	5
E	W	Kenya	Togo	20%	5	5	44
E	S	Zimbabwe	South Africa	20%	5	5	45
C	E	Cameroon	Tanzania	20%	1	7	3
C	E	Cameroon	Uganda	20%	1	7	3
E	E	Kenya	Zimbabwe	20%	1	5	5
E	E	Somalia	Ethiopia	20%	1	5	5
E	E	Somalia	Zimbabwe	20%	1	5	5
E	W	Zimbabwe	Senegal	20%	1	5	5
N	N	Sudan	Morocco	20%	1	1	9
W	N	Madagascar	Morocco	20%	1	1	9
C	W	Cameroon	Togo	20%	5	7	44
W	W	Nigeria	Burkina Faso	19%	2	13	8
W	W	Nigeria	Ghana	19%	2	13	8
N	W	Morocco	Nigeria	18%	2	9	13
W	E	Mozambique	Eritrea	18%	1	10	1
W	E	Mozambique	Madagascar	18%	1	10	1
W	N	Mozambique	Sudan	18%	1	10	1
N	S	Morocco	Botswana	18%	1	9	2
N	S	Morocco	Swaziland	18%	1	9	2
C	E	Cameroon	Malawi	18%	1	7	4
W	W	Tanzania	Ghana	18%	1	3	8
W	W	Uganda	Ghana	18%	1	3	8
N	W	Morocco	Niger	17%	2	9	14
E	W	Mozambique	Niger	17%	2	10	14
C	E	Cameroon	Zimbabwe	17%	1	7	5
W	N	Tanzania	Morocco	17%	1	3	9
W	N	Zambia	Morocco	17%	1	3	9
S	S	South Africa	Namibia	16%	4	45	4
E	W	Ethiopia	Togo	16%	4	5	44
E	W	Somalia	Togo	16%	4	5	44
E	S	Malawi	South Africa	16%	4	4	45
E	S	Ethiopia	South Africa	16%	4	5	45

SI D. (Continued)

Region A	Region B	Country A	Country B	Sorensen similarity %	No. species in country A	No. species in country B	No. Shared species
W	W	Uganda	Mali	16%	2	3	22
S	W	South Africa	Togo	16%	7	45	44
W	E	Mozambique	Tanzania	15%	1	10	3
W	E	Mozambique	Uganda	15%	1	10	3
N	S	Morocco	Namibia	15%	1	9	4
E	W	Ethiopia	Burkina Faso	15%	1	5	8
E	W	Ethiopia	Ghana	15%	1	5	8
E	W	Kenya	Burkina Faso	15%	1	5	8
E	W	Kenya	Ghana	15%	1	5	8
E	N	Malawi	Morocco	15%	1	4	9
E	W	Ethiopia	Mali	15%	2	5	22
E	W	Kenya	Mali	15%	2	5	22
W	W	Tanzania	Benin	14%	1	3	11
W	W	Zambia	Benin	14%	1	3	11
N	W	Sudan	Nigeria	14%	1	1	13
W	W	Madagascar	Nigeria	14%	1	1	13
S	W	South Africa	Nigeria	14%	4	45	13
S	W	Botswana	Nigeria	13%	1	2	13
S	W	Swaziland	Nigeria	13%	1	2	13
N	W	Sudan	Niger	13%	1	1	14
W	W	Madagascar	Niger	13%	1	1	14
N	W	Morocco	Mali	13%	2	9	22
W	W	Uganda	Togo	13%	3	3	44
E	W	Malawi	Togo	13%	3	4	44
W	S	Zambia	South Africa	13%	3	3	45
C	N	Cameroon	Morocco	13%	1	7	9
E	W	Ethiopia	Benin	13%	1	5	11
E	W	Kenya	Benin	13%	1	5	11
W	W	Tanzania	Nigeria	13%	1	3	13
S	W	Botswana	Niger	13%	1	2	14
S	W	Swaziland	Niger	13%	1	2	14
E	S	Kenya	South Africa	12%	3	5	45
E	S	Somalia	South Africa	12%	3	5	45
N	W	Morocco	Burkina Faso	12%	1	9	8
N	W	Morocco	Ghana	12%	1	9	8
S	W	Namibia	Nigeria	12%	1	4	13

SI D. (Continued)

Region A	Region B	Country A	Country B	Sorensen similarity %	No. species in country A	No. species in country B	No. Shared species
E	W	Zimbabwe	Nigeria	11%	1	5	13
S	W	Namibia	Niger	11%	1	4	14
S	W	South Africa	Benin	11%	3	45	11
E	N	Mozambique	Morocco	11%	1	10	9
E	W	Zimbabwe	Niger	11%	1	5	14
S	W	South Africa	Niger	10%	3	45	14
N	W	Morocco	Benin	10%	1	9	11
S	S	South Africa	Botswana	9%	2	45	2
S	S	South Africa	Swaziland	9%	2	45	2
W	W	Tanzania	Togo	9%	2	3	44
W	W	Zambia	Togo	9%	2	3	44
S	W	Namibia	Togo	8%	2	4	44
E	W	Zimbabwe	Togo	8%	2	5	44
S	W	South Africa	Senegal	8%	2	45	5
W	W	Tanzania	Mali	8%	1	3	22
W	W	Zambia	Mali	8%	1	3	22
C	S	Cameroon	South Africa	8%	2	7	45
E	W	Malawi	Mali	8%	1	4	22
N	W	Morocco	Togo	8%	2	9	44
E	W	Zimbabwe	Mali	7%	1	5	22
N	W	Tunisia	Mali	7%	1	6	22
E	W	Mozambique	Mali	6%	1	10	22
S	W	South Africa	Mali	6%	2	45	22
N	W	Sudan	Togo	4%	1	1	44
W	W	Eritrea	Togo	4%	1	1	44
W	W	Madagascar	Togo	4%	1	1	44
S	W	Botswana	Togo	4%	1	2	44
S	W	Swaziland	Togo	4%	1	2	44
N	S	Sudan	South Africa	4%	1	1	45
W	S	Madagascar	South Africa	4%	1	1	45
W	S	Tanzania	South Africa	4%	1	3	45
W	S	Uganda	South Africa	4%	1	3	45
N	S	Morocco	South Africa	4%	1	9	45
S	W	South Africa	Burkina Faso	0%	0	45	8
S	W	South Africa	Ghana	0%	0	45	8

SI D. (Continued)

Region A	Region B	Country A	Country B	Sorensen similarity %	No. species in country A	No. species in country B	No. Shared species
E	W	Mozambique	Benin	0%	0	10	11
E	W	Mozambique	Burkina Faso	0%	0	10	8
E	W	Mozambique	Ghana	0%	0	10	8
E	N	Mozambique	Tunisia	0%	0	10	6
C	N	Cameroon	Tunisia	0%	0	7	6
C	E	Cameroon	Somalia	0%	0	7	5
C	S	Cameroon	Namibia	0%	0	7	4
C	E	Cameroon	Zambia	0%	0	7	3
C	S	Cameroon	Botswana	0%	0	7	2
C	S	Cameroon	Swaziland	0%	0	7	2
C	C	Cameroon	Congo	0%	0	7	1
C	E	Cameroon	Eritrea	0%	0	7	1
C	C	Cameroon	Gabon	0%	0	7	1
C	E	Cameroon	Madagascar	0%	0	7	1
C	N	Cameroon	Sudan	0%	0	7	1
N	S	Tunisia	South Africa	0%	0	6	45
N	W	Tunisia	Togo	0%	0	6	44
N	W	Tunisia	Niger	0%	0	6	14
N	W	Tunisia	Nigeria	0%	0	6	13
N	W	Tunisia	Benin	0%	0	6	11
N	W	Tunisia	Burkina Faso	0%	0	6	8
N	W	Tunisia	Ghana	0%	0	6	8
N	W	Tunisia	Senegal	0%	0	6	5
N	S	Tunisia	Namibia	0%	0	6	4
N	S	Tunisia	Botswana	0%	0	6	2
N	S	Tunisia	Swaziland	0%	0	6	2
E	W	Somalia	Mali	0%	0	5	22
E	W	Somalia	Niger	0%	0	5	14
E	W	Somalia	Nigeria	0%	0	5	13
E	W	Somalia	Benin	0%	0	5	11
E	W	Zimbabwe	Benin	0%	0	5	11
E	N	Somalia	Morocco	0%	0	5	9
E	N	Zimbabwe	Morocco	0%	0	5	9
E	W	Somalia	Burkina Faso	0%	0	5	8
E	W	Somalia	Ghana	0%	0	5	8
E	W	Zimbabwe	Burkina Faso	0%	0	5	8

SI D. (Continued)

Region A	Region B	Country A	Country B	Sorensen similarity %	No. species in country A	No. species in country B	No. Shared species
E	W	Zimbabwe	Ghana	0%	0	5	8
E	N	Ethiopia	Tunisia	0%	0	5	6
E	N	Kenya	Tunisia	0%	0	5	6
E	N	Somalia	Tunisia	0%	0	5	6
E	N	Zimbabwe	Tunisia	0%	0	5	6
E	W	Somalia	Senegal	0%	0	5	5
W	E	Somalia	Tanzania	0%	0	5	3
W	E	Somalia	Uganda	0%	0	5	3
W	E	Somalia	Zambia	0%	0	5	3
W	E	Zimbabwe	Uganda	0%	0	5	3
W	S	Somalia	Botswana	0%	0	5	2
W	S	Somalia	Swaziland	0%	0	5	2
W	E	Somalia	Madagascar	0%	0	5	1
W	N	Somalia	Sudan	0%	0	5	1
W	E	Zimbabwe	Madagascar	0%	0	5	1
W	N	Zimbabwe	Sudan	0%	0	5	1
S	W	Namibia	Mali	0%	0	4	22
S	W	Namibia	Benin	0%	0	4	11
E	W	Malawi	Benin	0%	0	4	11
S	W	Namibia	Burkina Faso	0%	0	4	8
S	W	Namibia	Ghana	0%	0	4	8
E	W	Malawi	Burkina Faso	0%	0	4	8
E	W	Malawi	Ghana	0%	0	4	8
E	N	Malawi	Tunisia	0%	0	4	6
W	W	Tanzania	Burkina Faso	0%	0	3	8
W	W	Zambia	Burkina Faso	0%	0	3	8
W	W	Zambia	Ghana	0%	0	3	8
W	N	Tanzania	Tunisia	0%	0	3	6
W	N	Uganda	Tunisia	0%	0	3	6
W	N	Zambia	Tunisia	0%	0	3	6
W	E	Tanzania	Zimbabwe	0%	0	3	5
W	E	Tanzania	Eritrea	0%	0	3	1
S	W	Botswana	Mali	0%	0	2	22
S	W	Swaziland	Mali	0%	0	2	22
S	W	Botswana	Benin	0%	0	2	11

SI D. (Continued)

Region A	Region B	Country A	Country B	Sorensen similarity %	No. species in country A	No. species in country B	No. Shared species
S	W	Swaziland	Benin	0%	0	2	11
S	W	Botswana	Burkina Faso	0%	0	2	8
S	W	Botswana	Ghana	0%	0	2	8
S	W	Swaziland	Burkina Faso	0%	0	2	8
S	W	Swaziland	Ghana	0%	0	2	8
C	S	Congo	South Africa	0%	0	1	45
C	S	Gabon	South Africa	0%	0	1	45
W	S	Eritrea	South Africa	0%	0	1	45
C	W	Congo	Togo	0%	0	1	44
C	W	Gabon	Togo	0%	0	1	44
C	W	Congo	Mali	0%	0	1	22
C	W	Gabon	Mali	0%	0	1	22
N	W	Sudan	Mali	0%	0	1	22
W	W	Eritrea	Mali	0%	0	1	22
W	W	Madagascar	Mali	0%	0	1	22
C	W	Congo	Niger	0%	0	1	14
C	W	Gabon	Niger	0%	0	1	14
W	W	Eritrea	Niger	0%	0	1	14
C	W	Congo	Nigeria	0%	0	1	13
C	W	Gabon	Nigeria	0%	0	1	13
W	W	Eritrea	Nigeria	0%	0	1	13
C	W	Congo	Benin	0%	0	1	11
C	W	Gabon	Benin	0%	0	1	11
N	W	Sudan	Benin	0%	0	1	11
W	W	Eritrea	Benin	0%	0	1	11
W	W	Madagascar	Benin	0%	0	1	11
C	E	Congo	Mozambique	0%	0	1	10
C	E	Gabon	Mozambique	0%	0	1	10
C	N	Congo	Morocco	0%	0	1	9
C	N	Gabon	Morocco	0%	0	1	9
W	N	Eritrea	Morocco	0%	0	1	9
C	W	Congo	Burkina Faso	0%	0	1	8
C	W	Congo	Ghana	0%	0	1	8
C	W	Gabon	Burkina Faso	0%	0	1	8
C	W	Gabon	Ghana	0%	0	1	8

SI D. (Continued)

Region A	Region B	Country A	Country B	Sorensen similarity %	No. species in country A	No. species in country B	No. Shared species
N	W	Sudan	Burkina Faso	0%	0	1	8
N	W	Sudan	Ghana	0%	0	1	8
W	W	Eritrea	Burkina Faso	0%	0	1	8
W	W	Eritrea	Ghana	0%	0	1	8
W	W	Madagascar	Burkina Faso	0%	0	1	8
W	W	Madagascar	Ghana	0%	0	1	8
C	N	Congo	Tunisia	0%	0	1	6
C	N	Gabon	Tunisia	0%	0	1	6
N	N	Sudan	Tunisia	0%	0	1	6
W	N	Eritrea	Tunisia	0%	0	1	6
W	N	Madagascar	Tunisia	0%	0	1	6
C	E	Congo	Ethiopia	0%	0	1	5
C	E	Congo	Kenya	0%	0	1	5
C	W	Congo	Senegal	0%	0	1	5
C	E	Congo	Somalia	0%	0	1	5
C	E	Congo	Zimbabwe	0%	0	1	5
C	E	Gabon	Ethiopia	0%	0	1	5
C	E	Gabon	Kenya	0%	0	1	5
C	W	Gabon	Senegal	0%	0	1	5
C	E	Gabon	Somalia	0%	0	1	5
C	E	Gabon	Zimbabwe	0%	0	1	5
W	E	Eritrea	Ethiopia	0%	0	1	5
W	W	Eritrea	Senegal	0%	0	1	5
W	E	Eritrea	Zimbabwe	0%	0	1	5
C	E	Congo	Malawi	0%	0	1	4
C	S	Congo	Namibia	0%	0	1	4
C	E	Gabon	Malawi	0%	0	1	4
C	S	Gabon	Namibia	0%	0	1	4
W	E	Eritrea	Malawi	0%	0	1	4
W	S	Eritrea	Namibia	0%	0	1	4
C	E	Congo	Tanzania	0%	0	1	3
C	E	Congo	Uganda	0%	0	1	3
C	E	Congo	Zambia	0%	0	1	3
C	E	Gabon	Tanzania	0%	0	1	3
C	E	Gabon	Uganda	0%	0	1	3

SI D. (Continued)

Region A	Region B	Country A	Country B	Sorensen similarity %	No. Species in country A	No. Species in country B	No. Shared species
C	E	Gabon	Zambia	0%	0	1	3
W	E	Eritrea	Uganda	0%	0	1	3
W	E	Eritrea	Zambia	0%	0	1	3
C	S	Congo	Botswana	0%	0	1	2
C	S	Congo	Swaziland	0%	0	1	2
C	S	Gabon	Botswana	0%	0	1	2
C	S	Gabon	Swaziland	0%	0	1	2
W	S	Eritrea	Botswana	0%	0	1	2
W	S	Eritrea	Swaziland	0%	0	1	2
C	E	Congo	Eritrea	0%	0	1	1
C	E	Congo	Madagascar	0%	0	1	1
C	N	Congo	Sudan	0%	0	1	1
C	E	Gabon	Eritrea	0%	0	1	1
C	E	Gabon	Madagascar	0%	0	1	1
C	N	Gabon	Sudan	0%	0	1	1
W	E	Eritrea	Madagascar	0%	0	1	1
W	N	Eritrea	Sudan	0%	0	1	1

Supplementary Information E. The percentage of morphospecies similarity across 30 countries recorded. The percentage similarities are given from highest to lowest in a descending order. The grey shaded rows highlights comparison of different regions.

Region A	Region B	Country A	Country B	Sorensen similarity %	No. Morphospecies in country A	No. Morphospecies in country B	No. Shared morphospecies across country A and B
East	East	Kenya	Malawi	100%	5	5	5
E	West	Uganda	Senegal	100%	3	3	3
Central	C	Gabon	Congo	100%	1	1	1
W	W	Benin	Nigeria	90%	10	10	9
W	W	Nigeria	Niger	90%	10	10	9
W	W	Niger	Ghana	90%	10	10	9
South	W	South Africa	Togo	90%	16	13	13
W	W	Benin	Togo	87%	10	13	10
W	W	Nigeria	Togo	87%	10	13	10
W	W	Mali	Niger	86%	11	10	9
E	S	Uganda	Botswana	86%	3	4	3
S	W	Botswana	Senegal	86%	4	3	3
W	W	Mali	Togo	83%	11	13	10
C	E	Cameroon	Ethiopia	83%	6	6	5
North	N	Morocco	Tunisia	82%	10	7	7
W	W	Benin	Niger	80%	10	10	8
W	W	Nigeria	Ghana	80%	10	10	8
E	E	Kenya	Tanzania	80%	5	5	4
E	E	Tanzania	Malawi	80%	5	5	4
E	S	Zambia	Swaziland	80%	3	2	2
E	S	Uganda	Swaziland	80%	3	2	2
S	W	Swaziland	Senegal	80%	2	3	2
N	W	Morocco	Togo	78%	10	13	9
W	W	Togo	Niger	78%	13	10	9
W	W	Togo	Ghana	78%	13	10	9
W	W	Mali	Burkina Faso	78%	11	7	7
S	W	South Africa	Benin	77%	16	10	10
S	W	South Africa	Nigeria	77%	16	10	10
S	W	Namibia	Burkina Faso	77%	6	7	5
W	W	Benin	Mali	76%	10	11	8
W	W	Mali	Nigeria	76%	11	10	8
W	W	Mali	Ghana	76%	11	10	8
C	W	Cameroon	Benin	75%	6	10	6
C	W	Cameroon	Nigeria	75%	6	10	6

SI E. (Continued)

Region A	Region B	Country A	Country B	Sorensen similarity %	No. Morphospecies in country A	No. Morphospecies in country B	No. Shared Morphospecies across country A and B
S	W	Namibia	Benin	75%	6	10	6
E	E	Kenya	Uganda	75%	5	3	3
E	W	Kenya	Senegal	75%	5	3	3
E	E	Malawi	Uganda	75%	5	3	3
E	W	Malawi	Senegal	75%	5	3	3
S	W	South Africa	Mali	74%	16	11	10
C	E	Cameroon	Kenya	73%	6	5	4
C	E	Cameroon	Malawi	73%	6	5	4
C	E	Cameroon	Zimbabwe	73%	6	5	4
E	E	Kenya	Ethiopia	73%	5	6	4
E	E	Ethiopia	Malawi	73%	6	5	4
E	E	Ethiopia	Zimbabwe	73%	6	5	4
E	S	Zimbabwe	Namibia	73%	5	6	4
E	S	Mozambique	South Africa	72%	9	16	9
E	E	Mozambique	Kenya	71%	9	5	5
E	E	Mozambique	Malawi	71%	9	5	5
N	W	Morocco	Burkina Faso	71%	10	7	6
N	W	Tunisia	Ghana	71%	7	10	6
W	W	Benin	Burkina Faso	71%	10	7	6
W	W	Nigeria	Burkina Faso	71%	10	7	6
W	W	Niger	Burkina Faso	71%	10	7	6
E	W	Mozambique	Mali	70%	9	11	7
N	W	Morocco	Nigeria	70%	10	10	7
N	W	Morocco	Niger	70%	10	10	7
N	W	Morocco	Ghana	70%	10	10	7
W	W	Benin	Ghana	70%	10	10	7
W	W	Togo	Burkina Faso	70%	13	7	7
N	S	Morocco	South Africa	69%	10	16	9
S	W	South Africa	Niger	69%	16	10	9
S	W	South Africa	Ghana	69%	16	10	9
N	W	Morocco	Mali	67%	10	11	7
C	E	Cameroon	Mozambique	67%	6	9	5
E	N	Kenya	Morocco	67%	5	10	5
E	N	Tanzania	Morocco	67%	5	10	5
E	N	Malawi	Morocco	67%	5	10	5

SI E. (Continued)

Region A	Region B	Country A	Country B	Sorensen similarity %	No. Morphospecies in country A	No. Morphospecies in country B	No. Shared morphospecies across country A and B
E	W	Zimbabwe	Benin	67%	5	10	5
E	W	Zimbabwe	Nigeria	67%	5	10	5
C	S	Cameroon	Namibia	67%	6	6	4
E	W	Kenya	Burkina Faso	67%	5	7	4
E	S	Ethiopia	Namibia	67%	6	6	4
E	W	Malawi	Burkina Faso	67%	5	7	4
E	W	Zimbabwe	Burkina Faso	67%	5	7	4
C	E	Cameroon	Zambia	67%	6	3	3
C	E	Cameroon	Uganda	67%	6	3	3
C	W	Cameroon	Senegal	67%	6	3	3
E	S	Kenya	Botswana	67%	5	4	3
E	E	Ethiopia	Uganda	67%	6	3	3
E	W	Ethiopia	Senegal	67%	6	3	3
E	S	Malawi	Botswana	67%	5	4	3
E	E	Zambia	Uganda	67%	3	3	2
E	W	Zambia	Senegal	67%	3	3	2
S	S	Botswana	Swaziland	67%	4	2	2
E	E	Eritrea	Madagascar	67%	1	2	1
E	N	Madagascar	Sudan	67%	2	1	1
N	S	Sudan	Swaziland	67%	1	2	1
E	W	Mozambique	Togo	64%	9	13	7
C	W	Cameroon	Togo	63%	6	13	6
E	N	Mozambique	Morocco	63%	9	10	6
E	W	Mozambique	Benin	63%	9	10	6
E	W	Mozambique	Nigeria	63%	9	10	6
E	W	Mozambique	Niger	63%	9	10	6
E	W	Ethiopia	Togo	63%	6	13	6
S	W	Namibia	Togo	63%	6	13	6
C	W	Cameroon	Niger	63%	6	10	5
E	W	Mozambique	Burkina Faso	63%	9	7	5
E	W	Kenya	Mali	63%	5	11	5
E	N	Ethiopia	Morocco	63%	6	10	5
E	W	Ethiopia	Benin	63%	6	10	5
E	W	Ethiopia	Nigeria	63%	6	10	5
E	W	Malawi	Mali	63%	5	11	5

SI E. (Continued)

Region A	Region B	Country A	Country B	Sorensen similarity %	No. Morphospecies in country A	No. Morphospecies in country B	No. Shared morphospecies across country A and B
S	W	Namibia	Nigeria	63%	6	10	5
C	W	Cameroon	Burkina Faso	62%	6	7	4
E	S	Mozambique	Botswana	62%	9	4	4
E	W	Ethiopia	Burkina Faso	62%	6	7	4
S	W	South Africa	Burkina Faso	61%	16	7	7
N	W	Morocco	Benin	60%	10	10	6
N	W	Tunisia	Togo	60%	7	13	6
C	S	Cameroon	Botswana	60%	6	4	3
E	E	Kenya	Zimbabwe	60%	5	5	3
E	S	Ethiopia	Botswana	60%	6	4	3
E	E	Malawi	Zimbabwe	60%	5	5	3
E	W	Uganda	Burkina Faso	60%	3	7	3
W	W	Senegal	Burkina Faso	60%	3	7	3
C	W	Cameroon	Mali	59%	6	11	5
N	W	Tunisia	Nigeria	59%	7	10	5
N	W	Tunisia	Niger	59%	7	10	5
S	W	Namibia	Mali	59%	6	11	5
W	W	Ghana	Burkina Faso	59%	10	7	5
E	E	Mozambique	Tanzania	57%	9	5	4
E	E	Mozambique	Zimbabwe	57%	9	5	4
N	W	Tunisia	Burkina Faso	57%	7	7	4
E	E	Kenya	Madagascar	57%	5	2	2
E	S	Kenya	Swaziland	57%	5	2	2
E	E	Tanzania	Madagascar	57%	5	2	2
E	S	Tanzania	Swaziland	57%	5	2	2
E	S	Zambia	Botswana	57%	3	4	2
E	E	Malawi	Madagascar	57%	5	2	2
E	S	Malawi	Swaziland	57%	5	2	2
E	W	Kenya	Togo	56%	5	13	5
E	W	Tanzania	Togo	56%	5	13	5
E	W	Malawi	Togo	56%	5	13	5
E	W	Zimbabwe	Togo	56%	5	13	5
C	S	Cameroon	South Africa	55%	6	16	6
E	S	Ethiopia	South Africa	55%	6	16	6
S	S	South Africa	Namibia	55%	16	6	6

SI E. (Continued)

Region A	Region B	Country A	Country B	Sorensen similarity %	No. Morphospecies in country A	No. Morphospecies in country B	No. Shared morphospecies across country A and B
C	E	Cameroon	Tanzania	55%	6	5	3
E	S	Kenya	Namibia	55%	5	6	3
E	E	Tanzania	Ethiopia	55%	5	6	3
E	S	Tanzania	Namibia	55%	5	6	3
E	S	Malawi	Namibia	55%	5	6	3
S	W	Botswana	Burkina Faso	55%	4	7	3
E	E	Mozambique	Ethiopia	53%	9	6	4
E	S	Mozambique	Namibia	53%	9	6	4
E	W	Kenya	Benin	53%	5	10	4
E	W	Kenya	Nigeria	53%	5	10	4
E	W	Kenya	Niger	53%	5	10	4
E	W	Tanzania	Benin	53%	5	10	4
E	W	Tanzania	Nigeria	53%	5	10	4
E	W	Tanzania	Niger	53%	5	10	4
E	W	Malawi	Benin	53%	5	10	4
E	W	Malawi	Nigeria	53%	5	10	4
E	W	Malawi	Niger	53%	5	10	4
E	N	Zimbabwe	Morocco	53%	5	10	4
E	W	Zimbabwe	Niger	53%	5	10	4
E	W	Zimbabwe	Ghana	53%	5	10	4
E	W	Mozambique	Ghana	53%	9	10	5
N	S	Tunisia	South Africa	52%	7	16	6
C	N	Cameroon	Morocco	50%	6	10	4
C	W	Cameroon	Ghana	50%	6	10	4
E	W	Tanzania	Mali	50%	5	11	4
E	W	Ethiopia	Niger	50%	6	10	4
E	W	Ethiopia	Ghana	50%	6	10	4
E	W	Zimbabwe	Mali	50%	5	11	4
N	S	Morocco	Namibia	50%	10	6	4
S	W	Namibia	Niger	50%	6	10	4
E	E	Mozambique	Somalia	50%	9	3	3
E	E	Mozambique	Zambia	50%	9	3	3
E	E	Mozambique	Uganda	50%	9	3	3
E	W	Mozambique	Senegal	50%	9	3	3
E	W	Tanzania	Burkina Faso	50%	5	7	3

SI E. (Continued)

Region A	Region B	Country A	Country B	Sorensen similarity %	No. Morphospecies in country A	No. Morphospecies in country B	No. Shared morphospecies across country A and B
E	N	Zimbabwe	Tunisia	50%	5	7	3
C	S	Cameroon	Swaziland	50%	6	2	2
E	E	Kenya	Somalia	50%	5	3	2
E	E	Kenya	Zambia	50%	5	3	2
E	E	Somalia	Tanzania	50%	3	5	2
E	E	Somalia	Malawi	50%	3	5	2
E	E	Somalia	Zimbabwe	50%	3	5	2
E	E	Tanzania	Zambia	50%	5	3	2
E	E	Tanzania	Uganda	50%	5	3	2
E	W	Tanzania	Senegal	50%	5	3	2
E	S	Ethiopia	Swaziland	50%	6	2	2
E	E	Zambia	Malawi	50%	3	5	2
E	E	Zimbabwe	Uganda	50%	5	3	2
E	W	Zimbabwe	Senegal	50%	5	3	2
S	S	Namibia	Swaziland	50%	6	2	2
E	E	Somalia	Eritrea	50%	3	1	1
E	N	Zambia	Sudan	50%	3	1	1
E	S	Madagascar	Swaziland	50%	2	2	1
E	N	Uganda	Sudan	50%	3	1	1
N	W	Sudan	Senegal	50%	1	3	1
E	S	Kenya	South Africa	48%	5	16	5
E	S	Tanzania	South Africa	48%	5	16	5
E	S	Malawi	South Africa	48%	5	16	5
E	S	Zimbabwe	South Africa	48%	5	16	5
E	W	Ethiopia	Mali	47%	6	11	4
N	W	Tunisia	Benin	47%	7	10	4
E	N	Somalia	Morocco	46%	3	10	3
E	N	Ethiopia	Tunisia	46%	6	7	3
E	W	Zambia	Benin	46%	3	10	3
E	W	Zambia	Nigeria	46%	3	10	3
E	W	Zambia	Niger	46%	3	10	3
E	N	Uganda	Morocco	46%	3	10	3
E	W	Uganda	Benin	46%	3	10	3
E	W	Uganda	Nigeria	46%	3	10	3
E	W	Uganda	Niger	46%	3	10	3

SI E. (Continued)

Region A	Region B	Country A	Country B	Sorensen similarity %	No. Morphospecies in country A	No. Morphospecies in country B	No. Shared morphospecies across country A and B
N	W	Morocco	Senegal	46%	10	3	3
W	W	Benin	Senegal	46%	10	3	3
W	W	Nigeria	Senegal	46%	10	3	3
W	W	Niger	Senegal	46%	10	3	3
N	W	Tunisia	Mali	44%	7	11	4
E	S	Somalia	Namibia	44%	3	6	2
E	S	Tanzania	Botswana	44%	5	4	2
E	E	Ethiopia	Zambia	44%	6	3	2
E	S	Zambia	Namibia	44%	3	6	2
E	S	Zimbabwe	Botswana	44%	5	4	2
E	S	Uganda	Namibia	44%	3	6	2
S	W	Namibia	Senegal	44%	6	3	2
S	W	Swaziland	Burkina Faso	44%	2	7	2
E	W	Somalia	Mali	43%	3	11	3
E	W	Zambia	Mali	43%	3	11	3
E	W	Uganda	Mali	43%	3	11	3
N	S	Morocco	Botswana	43%	10	4	3
S	W	Botswana	Benin	43%	4	10	3
S	W	Botswana	Nigeria	43%	4	10	3
S	W	Botswana	Niger	43%	4	10	3
W	W	Mali	Senegal	43%	11	3	3
S	S	South Africa	Botswana	40%	16	4	4
E	W	Kenya	Ghana	40%	5	10	3
E	W	Tanzania	Ghana	40%	5	10	3
E	W	Malawi	Ghana	40%	5	10	3
S	W	Botswana	Mali	40%	4	11	3
E	N	Somalia	Tunisia	40%	3	7	2
E	W	Somalia	Burkina Faso	40%	3	7	2
E	E	Tanzania	Zimbabwe	40%	5	5	2
E	W	Zambia	Burkina Faso	40%	3	7	2
S	S	Botswana	Namibia	40%	4	6	2
C	E	Angola	Somalia	40%	2	3	1
C	E	Angola	Zambia	40%	2	3	1
E	E	Somalia	Madagascar	40%	3	2	1
E	E	Zambia	Madagascar	40%	3	2	1

SI E. (Continued)

Region A	Region B	Country A	Country B	Sorensen similarity %	No. Morphospecies in country A	No. Morphospecies in country B	No. Shared morphospecies across country A and B
E	E	Madagascar	Uganda	40%	2	3	1
E	W	Madagascar	Senegal	40%	2	3	1
N	S	Sudan	Botswana	40%	1	4	1
E	N	Mozambique	Tunisia	38%	9	7	3
E	W	Somalia	Togo	38%	3	13	3
E	W	Zambia	Togo	38%	3	13	3
E	W	Uganda	Togo	38%	3	13	3
S	W	Namibia	Ghana	38%	6	10	3
W	W	Togo	Senegal	38%	13	3	3
C	E	Angola	Mozambique	36%	2	9	2
E	E	Mozambique	Madagascar	36%	9	2	2
E	S	Mozambique	Swaziland	36%	9	2	2
S	W	Botswana	Togo	35%	4	13	3
C	W	Angola	Benin	33%	2	10	2
C	W	Angola	Nigeria	33%	2	10	2
C	W	Angola	Niger	33%	2	10	2
C	W	Angola	Ghana	33%	2	10	2
E	N	Kenya	Tunisia	33%	5	7	2
E	N	Tanzania	Tunisia	33%	5	7	2
E	N	Malawi	Tunisia	33%	5	7	2
E	N	Madagascar	Morocco	33%	2	10	2
N	S	Morocco	Swaziland	33%	10	2	2
S	W	Swaziland	Benin	33%	2	10	2
S	W	Swaziland	Nigeria	33%	2	10	2
S	W	Swaziland	Niger	33%	2	10	2
E	E	Kenya	Eritrea	33%	5	1	1
E	N	Kenya	Sudan	33%	5	1	1
E	E	Tanzania	Eritrea	33%	5	1	1
E	N	Tanzania	Sudan	33%	5	1	1
E	E	Eritrea	Malawi	33%	1	5	1
E	N	Malawi	Sudan	33%	5	1	1
E	S	Madagascar	Botswana	33%	2	4	1
E	S	Somalia	South Africa	32%	3	16	3
E	S	Zambia	South Africa	32%	3	16	3
E	S	Uganda	South Africa	32%	3	16	3

SI E. (Continued)

Region A	Region B	Country A	Country B	Sorensen similarity %	No. Morphospecies in country A	No. Morphospecies in country B	No. Shared morphospecies across country A and B
S	W	South Africa	Senegal	32%	16	3	3
C	N	Cameroon	Tunisia	31%	6	7	2
C	W	Angola	Mali	31%	2	11	2
E	W	Somalia	Benin	31%	3	10	2
E	W	Somalia	Nigeria	31%	3	10	2
E	W	Somalia	Niger	31%	3	10	2
E	W	Somalia	Ghana	31%	3	10	2
E	N	Zambia	Morocco	31%	3	10	2
E	W	Zambia	Ghana	31%	3	10	2
E	W	Madagascar	Mali	31%	2	11	2
E	W	Uganda	Ghana	31%	3	10	2
N	S	Tunisia	Namibia	31%	7	6	2
S	W	Swaziland	Mali	31%	2	11	2
W	W	Ghana	Senegal	31%	10	3	2
S	W	Botswana	Ghana	29%	4	10	2
C	N	Cameroon	Sudan	29%	6	1	1
C	E	Angola	Zimbabwe	29%	2	5	1
C	S	Gabon	Namibia	29%	1	6	1
C	S	Congo	Namibia	29%	1	6	1
E	N	Ethiopia	Sudan	29%	6	1	1
E	S	Zimbabwe	Swaziland	29%	5	2	1
N	S	Sudan	Namibia	29%	1	6	1
C	W	Angola	Togo	27%	2	13	2
E	W	Madagascar	Togo	27%	2	13	2
S	W	Swaziland	Togo	27%	2	13	2
C	C	Cameroon	Angola	25%	6	2	1
C	E	Cameroon	Madagascar	25%	6	2	1
C	S	Angola	Namibia	25%	2	6	1
C	W	Gabon	Burkina Faso	25%	1	7	1
C	W	Congo	Burkina Faso	25%	1	7	1
E	E	Ethiopia	Madagascar	25%	6	2	1
E	E	Zambia	Zimbabwe	25%	3	5	1
E	S	Madagascar	Namibia	25%	2	6	1
N	W	Sudan	Burkina Faso	25%	1	7	1
C	S	Angola	South Africa	22%	2	16	2

SI E. (Continued)

Region A	Region B	Country A	Country B	Sorensen similarity %	No. Morphospecies in country A	No. Morphospecies in country B	No. Shared morphospecies across country A and B
E	S	Madagascar	South Africa	22%	2	16	2
S	S	South Africa	Swaziland	22%	16	2	2
C	E	Cameroon	Somalia	22%	6	3	1
C	N	Angola	Tunisia	22%	2	7	1
C	W	Angola	Burkina Faso	22%	2	7	1
E	E	Somalia	Ethiopia	22%	3	6	1
E	W	Madagascar	Burkina Faso	22%	2	7	1
E	E	Mozambique	Eritrea	20%	9	1	1
E	N	Mozambique	Sudan	20%	9	1	1
E	N	Uganda	Tunisia	20%	3	7	1
N	W	Tunisia	Senegal	20%	7	3	1
C	W	Gabon	Benin	18%	1	10	1
C	W	Congo	Benin	18%	1	10	1
E	N	Eritrea	Morocco	18%	1	10	1
N	N	Sudan	Morocco	18%	1	10	1
N	W	Sudan	Benin	18%	1	10	1
N	W	Sudan	Nigeria	18%	1	10	1
N	W	Sudan	Niger	18%	1	10	1
N	S	Tunisia	Botswana	18%	7	4	1
C	N	Angola	Morocco	17%	2	10	1
C	W	Gabon	Mali	17%	1	11	1
C	W	Congo	Mali	17%	1	11	1
E	W	Eritrea	Mali	17%	1	11	1
E	W	Madagascar	Benin	17%	2	10	1
E	W	Madagascar	Nigeria	17%	2	10	1
E	W	Madagascar	Niger	17%	2	10	1
N	W	Sudan	Mali	17%	1	11	1
S	W	Swaziland	Ghana	17%	2	10	1
C	W	Gabon	Togo	14%	1	13	1
C	W	Congo	Togo	14%	1	13	1
E	W	Eritrea	Togo	14%	1	13	1
N	W	Sudan	Togo	14%	1	13	1
C	S	Gabon	South Africa	12%	1	16	1
C	S	Congo	South Africa	12%	1	16	1
E	S	Eritrea	South Africa	12%	1	16	1

SI E. (Continued)

Region A	Region B	Country A	Country B	Sorensen similarity %	No. Morphospecies in country A	No. Morphospecies in country B	No. Shared morphospecies across country A and B
N	S	Sudan	South Africa	12%	1	16	1
C	C	Cameroon	Gabon	0%	6	1	0
C	C	Cameroon	Congo	0%	6	1	0
C	E	Cameroon	Eritrea	0%	6	1	0
C	C	Angola	Gabon	0%	2	1	0
C	C	Angola	Congo	0%	2	1	0
C	E	Angola	Kenya	0%	2	5	0
C	E	Angola	Tanzania	0%	2	5	0
C	E	Angola	Eritrea	0%	2	1	0
C	E	Angola	Ethiopia	0%	2	6	0
C	E	Angola	Malawi	0%	2	5	0
C	E	Angola	Madagascar	0%	2	2	0
C	E	Angola	Uganda	0%	2	3	0
C	N	Angola	Sudan	0%	2	1	0
C	S	Angola	Botswana	0%	2	4	0
C	S	Angola	Swaziland	0%	2	2	0
C	W	Angola	Senegal	0%	2	3	0
C	E	Gabon	Mozambique	0%	1	9	0
C	E	Gabon	Kenya	0%	1	5	0
C	E	Gabon	Somalia	0%	1	3	0
C	E	Gabon	Tanzania	0%	1	5	0
C	E	Gabon	Eritrea	0%	1	1	0
C	E	Gabon	Ethiopia	0%	1	6	0
C	E	Gabon	Zambia	0%	1	3	0
C	E	Gabon	Malawi	0%	1	5	0
C	E	Gabon	Zimbabwe	0%	1	5	0
C	E	Gabon	Madagascar	0%	1	2	0
C	E	Gabon	Uganda	0%	1	3	0
C	N	Gabon	Sudan	0%	1	1	0
C	N	Gabon	Morocco	0%	1	10	0
C	N	Gabon	Tunisia	0%	1	7	0
C	S	Gabon	Botswana	0%	1	4	0
C	S	Gabon	Swaziland	0%	1	2	0
C	W	Gabon	Nigeria	0%	1	10	0
C	W	Gabon	Niger	0%	1	10	0

SI E. (Continued)

Region A	Region B	Country A	Country B	Sorensen similarity %	No. Morphospecies in country A	No. Morphospecies in country B	No. Shared morphospecies across country A and B
C	W	Gabon	Ghana	0%	1	10	0
C	W	Gabon	Senegal	0%	1	3	0
C	E	Congo	Mozambique	0%	1	9	0
C	E	Congo	Kenya	0%	1	5	0
C	E	Congo	Somalia	0%	1	3	0
C	E	Congo	Tanzania	0%	1	5	0
C	E	Congo	Eritrea	0%	1	1	0
C	E	Congo	Ethiopia	0%	1	6	0
C	E	Congo	Zambia	0%	1	3	0
C	E	Congo	Malawi	0%	1	5	0
C	E	Congo	Zimbabwe	0%	1	5	0
C	E	Congo	Madagascar	0%	1	2	0
C	E	Congo	Uganda	0%	1	3	0
C	N	Congo	Sudan	0%	1	1	0
C	N	Congo	Morocco	0%	1	10	0
C	N	Congo	Tunisia	0%	1	7	0
C	S	Congo	Botswana	0%	1	4	0
C	S	Congo	Swaziland	0%	1	2	0
C	W	Congo	Nigeria	0%	1	10	0
C	W	Congo	Niger	0%	1	10	0
C	W	Congo	Ghana	0%	1	10	0
C	W	Congo	Senegal	0%	1	3	0
E	E	Somalia	Zambia	0%	3	3	0
E	E	Somalia	Uganda	0%	3	3	0
E	N	Somalia	Sudan	0%	3	1	0
E	S	Somalia	Botswana	0%	3	4	0
E	S	Somalia	Swaziland	0%	3	2	0
E	W	Somalia	Senegal	0%	3	3	0
E	E	Eritrea	Ethiopia	0%	1	6	0
E	E	Eritrea	Zambia	0%	1	3	0
E	E	Eritrea	Zimbabwe	0%	1	5	0
E	E	Eritrea	Uganda	0%	1	3	0
E	N	Eritrea	Sudan	0%	1	1	0
E	N	Eritrea	Tunisia	0%	1	7	0
E	S	Eritrea	Botswana	0%	1	4	0

SI E. (Continued)

Region A	Region B	Country A	Country B	Sorensen similarity %	No. Morphospecies in country A	No. Morphospecies in country B	No. Shared morphospecies across country A and B
E	S	Eritrea	Namibia	0%	1	6	0
E	S	Eritrea	Swaziland	0%	1	2	0
E	W	Eritrea	Benin	0%	1	10	0
E	W	Eritrea	Nigeria	0%	1	10	0
E	W	Eritrea	Niger	0%	1	10	0
E	W	Eritrea	Ghana	0%	1	10	0
E	W	Eritrea	Senegal	0%	1	3	0
E	W	Eritrea	Burkina Faso	0%	1	7	0
E	N	Zambia	Tunisia	0%	3	7	0
E	E	Zimbabwe	Madagascar	0%	5	2	0
E	N	Zimbabwe	Sudan	0%	5	1	0
E	N	Madagascar	Tunisia	0%	2	7	0
E	W	Madagascar	Ghana	0%	2	10	0
N	N	Sudan	Tunisia	0%	1	7	0
N	W	Sudan	Ghana	0%	1	10	0
N	S	Tunisia	Swaziland	0%	7	2	0