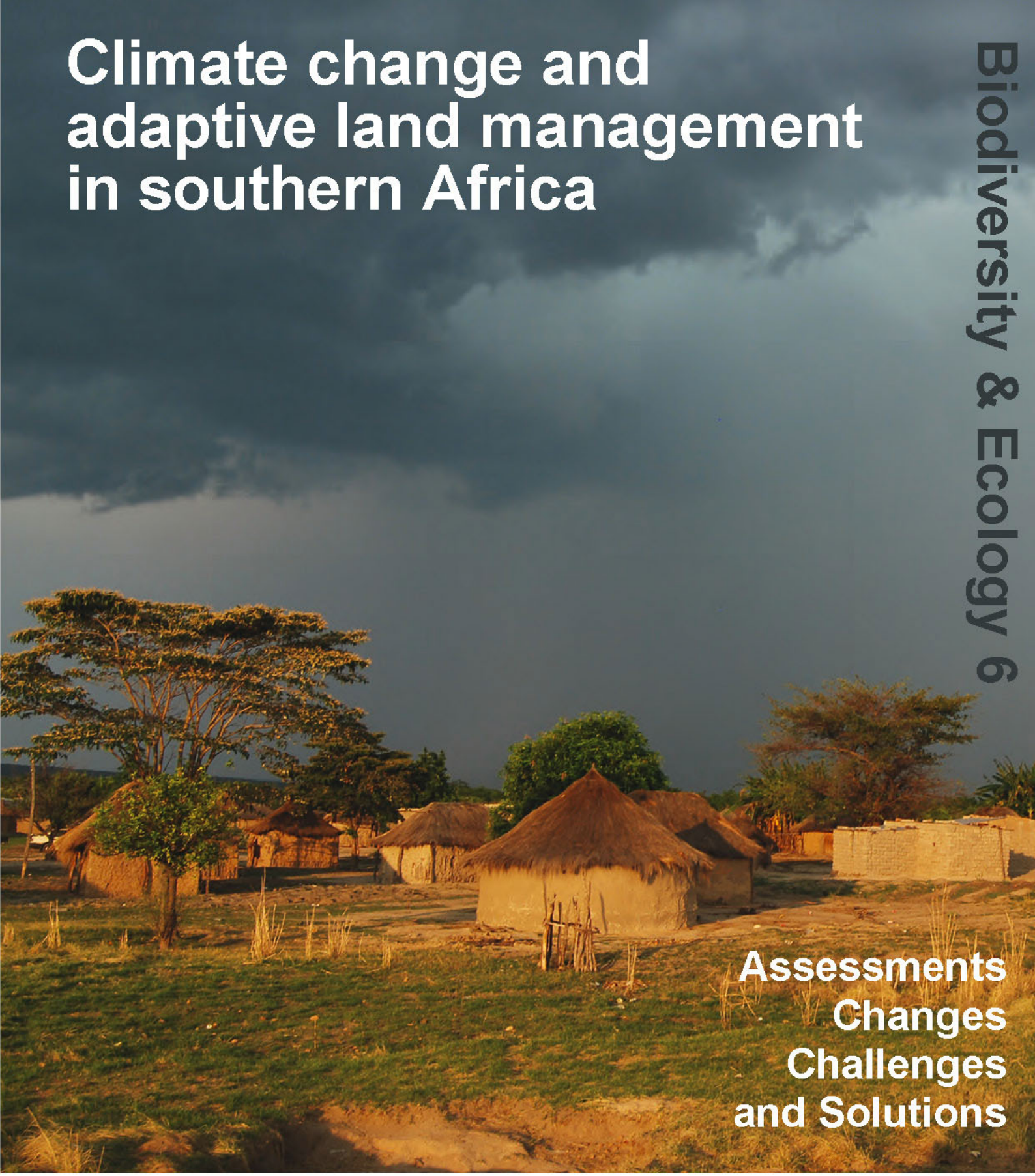
Climate change and adaptive land management in southern Africa

Biodiversity & Ecology 6



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Assessments, changes, challenges, and solutions

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Amphibians and reptiles of the Tundavala region of the Angolan Escarpment

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Abstract: The most poorly known section of the African Great Escarpment is located in Angola. It has been highlighted as a potential center of endemism for several biological groups, including herpetofauna. The region, which is critical for the conservation of Angolan biodiversity, requires urgent research. In the scope of the SASSCAL project, a herpetofauna monitoring plan is being implemented in Tundavala, in the southern Angolan escarpment. In total, 13 species of amphibians, 12 species of lizards and 9 species of snakes have been registered so far, and more are expected to occur. Among them are some important rediscoveries of Angolan endemics uncollected for decades, such as Anchieta's treefrog (*Leptopelis anchietae*) and Ansorge's whip snake (*Psammophis ansorgii*).

Resumo: A secção menos conhecida da Grande Escarpa Africana localiza-se em Angola. Esta já foi destacada como um potencial centro de endemismo para vários grupos, incluindo a herpetofauna, sendo por isso uma região crítica para a conservação da biodiversidade angolana que carece urgentemente de investigação. No âmbito do projecto SASSCAL, está a ser implementado um plano de monitorização de herpetofauna na Tundavala, no sul da escarpa de Angola. Até ao momento foram registadas 13 espécies de anfíbios, 12 espécies de lagartos e nove espécies de cobras, e presume-se que existam mais. Entre estas, estão redescobertas importantes de endemismos angolanos não registados há várias décadas, como a rã-arborícola-de-Anchieta (*Leptopelis anchietae*), e a cobra-de-Ansorge (*Psammophis ansorgii*).

Introduction

The Angolan section is the most poorly known of the African Great Escarpment, and yet it supports the highest number of vertebrate endemics after those in South Africa (Clark et al., 2011). It is rich in endemic plants and birds and is a potential hotspot for Angolan biodiversity (Hall, 1960). However, more research is required to identify and meaningfully implement conservation objectives, especially detailed biodiversity surveys and systematic studies. These will allow the effects of predicted climate change, highlighted by Clark et al. (2011), to be identified, and refugia and migration hypotheses to be formulated and tested.

Tundavala is located on the Angolan escarpment in southwestern Angola (Fig. 1), and its outstanding landscape makes it one of the most important tourist destinations in the country. The creation of a nature reserve in Tundavala was proposed by Huntley & Matos (1994), and the reserve is mentioned in the Angolan National Biodiversity Strategy and Action Plan (NBSAP, 2006) as a protected area to be implemented. It is also classified as an Important Bird Area (BirdLife International, 2017), and the Tundavala Crevice was classified as a Cultural Landscape in 2012 (Executive decree no. 261/12). Despite its social and biological importance, the region lacks official national protected status and is threatened by progressively increasing human activities, especially logging and burning for charcoal production and the harvesting of natural resources such as medicinal plants and rocks for building purposes. Increasing numbers of villagers inhabit the region with their livestock (cows and goats) and plant crops. Other threats include man-made fires and the dumping of rubble and domestic, commercial, and even medical waste.

Southwestern Angola is one of the better-surveyed regions of Angola for all vertebrate groups (Crawford-Cabral & Mesquitela, 1989), and the herpetofauna is no exception, with numerous studies addressing it (Bocage, 1895; Schmidt, 1933, 1936; Parker, 1936; Monard, 1937a,b; Mertens, 1938; Bogert, 1940; Loveridge, 1944; Hellmich, 1957; FitzSimons, 1959; Laurent, 1964; Poynton & Haacke, 1993; Haacke, 1997). Despite this, new species continue to be described from the region (Haacke, 2008; Conradie et al., 2012; Stanley et al., 2016). Little work has focused specifically on the escarpment region, and its herpetofauna is

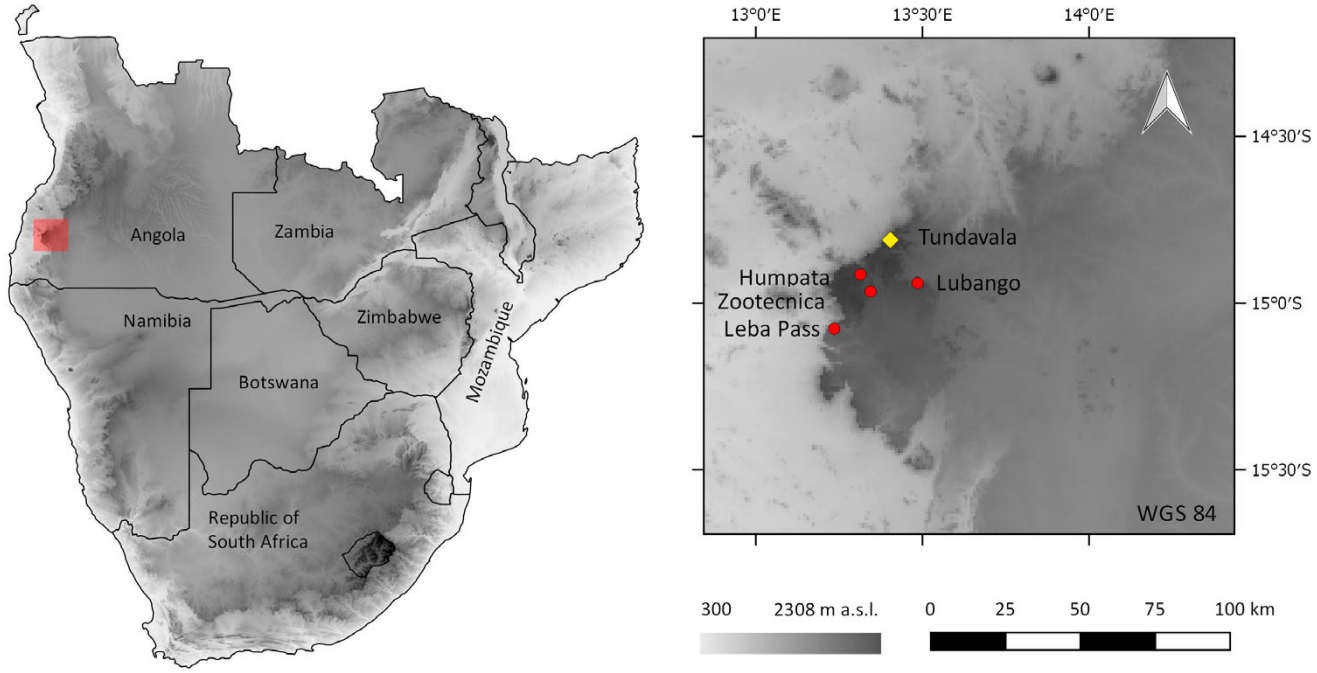

Figure 1: Left: Location of the study site in the African Great Escarpment. Right: Localities near the study area mentioned where additional species expected in Tundavala were recorded.

far from being completely understood. The Humpata Plateau, including Tundavala, has been identified as a potential center of endemism for montane herpetofauna and is therefore a priority area for herpetofaunal surveys (Laurent, 1964).

The main goal of the SASSCAL Project's observatories (task 210) is to monitor biodiversity to understand the effects of climate change and land use on plant communities in the long term. Several observatories have been implemented throughout Angola, including one in Tundavala. The herpetofauna is frequently cited as a useful indicator for environmental monitoring thanks to its importance in ecological functioning and its sensitivity to environmental change (Smith & Rissler, 2010). In this context, a monitoring program of the Tundavala herpetofauna was initiated in 2016. The compilation of baseline information, such as presence and absence of species and their relative abundances in the mid- and long term, is essential for the effective management of this critical region for the conservation of Angolan biodiversity. This is the first herpetofauna monitoring plan implemented in Angola. The project is ongoing, and preliminary and more relevant findings are presented in this publication.

Figure 2: Montane grassland (grassy habitat) at first monitoring site.

Figure 3: Weathered sandstone outcrops (rocky habitat) and associated woody and grassy vegetation at second monitoring site.

Common name	Species	Family
Anchieta's Treefrog	(E) *Leptopelis anchietae* (Bocage, 1873)	Arthroleptidae
Bocage's Treefrog	*Leptopelis* cf. *bocagii* (Günther, 1865)	Arthroleptidae
Guttural Toad	*Sclerophyrs* cf. *gutturalis* (Power, 1927)	Bufonidae
Flat-Backed Toad	*Sclerophrys* cf. *pusilla* (Mertens, 1937)	Bufonidae
Monard's Reed Frog	(E) *Hyperolius cinereus* Monard, 1937	Hyperoliidae
Angola Reed Frog	*Hyperolius* cf. *parallelus* Günther, 1858	Hyperoliidae
Benguela Long Reed Frog	*Hyperolius* cf. *benguellensis* (Bocage, 1893)	Hyperoliidae
Bubbling Kassina	*Kassina senegalensis* (Duméril and Bibron, 1841)	Hyperoliidae
Mababe Puddle Frog	*Phrynobatrachus* cf. *mababiensis* FitzSimons, 1932	Phrynobatrachidae
Peters' Clawed Frog	*Xenopus* cf. *petersii* Bocage, 1895	Pipidae
Anchieta's Ridged Frog	*Ptychadena* cf. *anchietae* (Bocage, 1868)	Ptychadenidae
Angola River Frog	*Amietia angolensis* (Bocage, 1866)	Pyxicephalidae
Rough Sand Frog	*Tomopterna* cf. *tuberculosa* (Boulenger, 1882)	Pyxicephalidae

Table 1: Amphibian species recorded from the Tundavala observatory and close surroundings. (E) indicates species endemic to the Angolan highlands.

Common name	Species	Family
	Lizards (Sauria)	
Ground Agama	*Agama* cf. *aculeata* (Merrem, 1820)	Agamidae
Namib Rock Agama	*Agama* cf. *planiceps* Peters, 1862	Agamidae
Double-scaled Chameleon	*Chamaeleo anchietae* Bocage, 1872	Chamaeleonidae
Machado's Girdled Lizard	(E) *Cordylus machadoi* Laurent, 1964	Cordylidae
Speckled Thick-toed Gecko	*Pachydactylus* cf. *punctatus* Peters, 1854	Gekkonidae
Montane Day Gecko	(E) * *Rhoptropus boultoni montanus* Laurent, 1964	Gekkonidae
Western Serpentiform Skink	*Eumecia anchietae* Bocage, 1870	Scincidae
Angola burrowing Skink	*Sepsina* cf. *angolensis* Bocage, 1866	Scincidae
Hoesch's skink	*Trachylepis hoeschi* (Mertens, 1954)	Scincidae
Western Rock Skink	(E) * *Trachylepis sulcata ansorgei* (Boulenger, 1907)	Scincidae
Variable Skink	*Trachylepis* cf. *varia* (Peters, 1867)	Scincidae
Wahlberg's Skink	*Trachylepis wahlbergi* (Peters, 1869)	Scincidae
	Snakes (Serpentes)	
Angolan Green Snake	*Philothamnus angolensis* (Bocage, 1882)	Colubridae
Confusing Egg-Eater	*Dasypelis* cf. *confusa* (Trape & Mané, 2006)	Colubridae
Anchieta's cobra	*Naja anchietae* Bocage, 1879	Elapidae
Viperine Rock Snake	*Hemirhagerrhis viperina* (Bocage, 1873)	Lamprophiidae
Spotted Wolf Snake	*Lycophidion* cf. *multimaculatum* Boettger, 1888	Lamprophiidae
Ansorge's Whip Snake	(E) *Psammophis ansorgii* (Boulenger, 1905)	Lamprophiidae
Mozambique Grass Snake	*Psammophis* cf. *mossambicus* (Peters, 1882)	Lamprophiidae
Ocellated Skaapsteker	(E) *Psammophylax rhombeatus ocellatus* (Bocage, 1873)	Lamprophiidae
Blind Snake	*Afrotyphlops* cf. *anomalus* (Bocage, 1873)	Typhlopidae

Table 2: Reptile species recorded from the Tundavala observatory and close surroundings. (E) indicates species endemic to the Angolan highlands. (*) indicates cases where taxonomy follows Laurent (1964).

Methods

Survey area

The Tundavala region of the plateau is composed of a mosaic of vegetation types and rugged topography. Patches of relict Afromontane forest with *Podocarpus milanjianus* occur in deep humid ravines and at altitudes above 1,800 m (Huntley & Matos, 1994). They co-occur on the escarpment plateau with patches of open *Protea* savanna, *Pteridium* bracken, miombo woodlands on sands, montane grasslands, thickets along seasonal streams, and poorly drained grassy patches in valleys (BirdLife International, 2017), and provide diverse habitats for the herpetofauna.

Monitoring

Herpetofauna monitoring in the SASSCAL Tundavala observatory region involved standardized sampling in the two habitat types occurring in the observatory area: sandy soils with montane grassland (grassy habitat, Figure 2), and "corridors" of undifferentiated woody montane communities between large weathered sandstone outcrops (rocky habitat, Figure 3). Preliminary herpetological surveys began in November 2015. Standardized monitoring was initiated in April 2016, with three monitoring sessions each year: following early rains (October–November), at the peak of the rainy season (February), and at the end of the rainy season (late April). Monitoring involves the installation of two 15-meter-long traplines, each associated with six funnel and two pit fall traps. These are placed for 14 consecutive days and are checked daily. In addition, 20 time-constrained transects with visual encounter surveys (VES) are done on sunny mornings (10) and afternoons (10). Both techniques are undertaken equally in grassy and rocky habitats. Additional VESs are undertaken opportunistically in unmonitored habitats during day and night, as are auditory surveys for adult frogs and tadpole sampling. Small mammals are also included in the Tundavala monitoring plan, but results are not addressed in the present work.

Reptiles and amphibians were collected and deposited in the herpetological collection currently deposited at the Instituto Superior de Ciências da Educação da Huíla (ISCED-Huíla), and tissue for genetic analysis has been preserved in 95% ethanol for use in ongoing and further research. Preliminary identification of species is based on Channing (2001, 2012) and Branch (1998), supplemented with taxa-specific literature when needed. Taxonomy follows Frost (2017) for amphibians and Uetz & Hošek (2017) for reptiles, except where noted. All pictures of landscape and animals are from Tundavala.

Results

Sampling success

Trapping success of herpetofauna at Tundavala has been low, regardless of the sampling season. In the four sampling seasons performed, fewer than 15 individuals were caught in the traplines, and in one sampling season in particular, only one individual was captured during the 14 days of sampling. As a result of low catch rates at Tundavala, the data do not allow in-depth or temporal analysis, and thus we will focus on the observed herpetofaunal diversity and its biogeographic importance.

Species list

A total of 13 species of frogs (Tab. 1), 12 species of lizards, and 9 species of snakes (Tab. 2) were recorded during the monitoring and opportunistic surveys in the observatory and close surroundings.

Most species were caught too few times to establish habitat associations. Some reptile species were regularly associated with rocky habitats (e.g., *Agama* cf. *planiceps, Rhoptropus b. montanus,* and *Hemirhagerrhis viperina*), whilst others were found in both habitats (e.g., *Psammophylax r. ocellatus*). As expected, most amphibians except *Sclerophrys* spp., *Tomopterna tuberculosa,* and *Leptopelis bocagii* were found only near water bodies.

Additional species recorded from Lubango and adjacent regions of the escarpment may be expected to occur in Tundavala given their habitat associations, but have not been recorded so far. Among these, some have been found in Humpata: snout burrower, *Hemisus* sp. (Branch et al., unpub. Data); long-headed tropical house gecko, *Hemidactylus longicephalus* Bocage, 1873; Angolan rough-scaled lizard, *Ichnotropis bivittata pallida* Laurent, 1964; Bayon's skink, *Trachylepis bayonii huilensis* (Laurent, 1964)*; Angolan garter snake, *Elapsoidea semiannulata* Bocage, 1882) (all records from Laurent, 1964). Others have been recorded in Lubango: African house snake, *Boaedon* cf. *fuliginosus* (Boie, 1827); leopard grass snake, *Psammophis leopardinus* Bocage, 1887; three-lined grass snake, *Psammophylax tritaeniatus* (Günther, 1868) (Vaz Pinto, pers. obs.), and in Lubango, Leba Pass, and the Estação Zootécnica: flap-necked chamaeleon, *Chamaeleo dilepis* (Leach, 1819) (Brach et al., unpub. data; Baptista, pers. obs.); flat gecko *Afroedura* sp., snake-eyed skink *Panaspis* sp. (Vaz Pinto & Baptista, *unpub. data*), and the endemic habitat specialist Chela reed frog, *Hyperolius chelaensis* (Conradie et al., 2012).

Discussion

Monitoring success

The herpetological monitoring program in the Tundavala observatory region has been of only limited success and requires adjustment. New approaches considered include surveys at different times during the day, checking traplines twice daily, and modifying the trapline arrangement to use a Y-shaped (3 arms of 15 m) array in grassy areas. Opportunistic acoustic surveys and tadpole collection proved productive and will be standardized and included in the monitoring plan on a systematic basis.

The Tundavala plateau has varied soils, geology, topography, and vegetation types that provide different habitats and microhabitats for the herpetofauna. Currently, systematic monitoring covers only two habitat types and therefore does not fully survey the entire herpetofaunal diversity of the plateau and the escarpment.

Species list, taxonomy, and conservation relevance

Many of the species listed in Tables 1 and 2 have been only provisionally identified. This reflects the current poor state of knowledge of the Angolan herpetofauna. Many of the provisional identifications involve wide-ranging species or species complexes in which cryptic diversity has recently been identified but for which no, or little, Angolan material was included. Other species are poorly known Angolan species, some known from very few specimens and for which the types were lost in the fire that destroyed the Lisbon Museum in 1978. These problematic species, of which some may be new to science, given the geographic setting of Tundavala, are either currently under investigation or will require further investigation when additional, often topotypic material becomes available. Taxonomic issues associated with some of these species are addressed below.

Figure 4: Anchieta's treefrog (*Leptopelis anchietae*), breeding male.

Leptopelis anchietae (Bocage, 1873)

This species is known from Missão da Huíla, Caconda, and Quindumbo (Bocage, 1895); "between Benguela and Bié" (Boulenger, 1905); Caluquembe, Ebanga, Missão do Cubango (Monard, 1937a); Chitau (Schmidt, 1936); and Alto Chicapa (Laurent, 1964). It is endemic to the Angolan plateau (Monard, 1937a). The specimens from Tundavala (Fig. 4) correspond in morphology and coloration with the type description and plate in Bocage (1895). Details of this rediscovery and those of other *Leptopelis* from northern areas of the Angolan escarpment will be presented elsewhere (Baptista et al., in prep.).

Leptopelis* cf. *bocagii (Günther, 1865)
This species, originally described from Calandula (formerly Duque de Bragança), is considered widespread in Africa, including the north, west, and south of Angola (Bocage, 1895; Ferreira, 1904, 1906; Schmidt, 1936; Monard, 1937a; Laurent, 1954, 1964; Hellmich, 1957; Laurent, 1954, 1964). It is thought to be a complex of cryptic species (Frost, 2017), and the availability of Angolan material on *Hylambates angolensis* Bocage, 1893, currently in the synonymy of *L. bocagii*, needs further study (Perret, 1967).

***Sclerophrys* spp.**
The status of the Angolan toad taxonomy needs to be readdressed (Ruas, 1996). *S. gutturalis* is widespread in the country, and the recently renamed *Sclerophrys pusilla* (Poynton et al., 2016) is known mostly from western Angola (Ruas, 1996). However, both species have wide distributions in Africa, and their taxonomy and the availability of names for Angolan material still requires further investigation..

Hyperolius cinereus Monard, 1937
An endemic from the Angolan plateau, historically known from only a few localities, this species' distribution has been found to be much more widespread (Conradie et al., 2016).

Figure 5: Angolan reed frog (*Hyperolius* cf. *parallelus*), breeding male.

Hyperolius* cf. *parallelus (Günther, 1858) and ***Hyperolius* cf. *benguellensis*** (Bocage, 1893)
Both these species consist of "super complexes" in Africa. *H. parallelus* is closely related to the problematic *H. marmoratus,* and *H.* cf. *benguellensis* belongs to the equally unresolved *H. nasutus* complex, which has recently been revised (Channing et al., 2013). Both species are widespread in Angola and have several names in their synonymy, with variations in shape, size, and coloration. Comprehensive studies, including wide geographical surveys combined with genetics and advertisement calls, are needed to resolve the taxonomy of both groups. An Angolan reed frog from Tundavala is shown in Figure 5.

Tomopterna* cf. *tuberculosa (Boulenger, 1882)
One of the most common species of frog in the monitoring region, with a variety of color morphs. Originally described from Pungo Andongo on the Angolan central plateau, this species is widespread in the country (Ruas, 1996), extends east to central coastal Mozambique, and may comprise a complex of cryptic species. Other available names for Angolan material currently subsumed under *T. tuberculosa* include *Rana cacondana* and *Rana signata*. Advertisement calls and genetics are crucial to resolving these issues.

Figure 6: Ocellated skaapsteker (*Psammophylax rhombeatus ocellatus*).

Psammophylax rhombeatus ocellatus (Bocage, 1873)
This taxon has morphological differences (Fig. 6) and is separated from the typical race in South Africa, with a few scattered records in northern Namibia (Kamanjab [Broadley, 1977]; Kaross [Hoffman, 1989]). Its status as a full species is currently being investigated (Branch et al., in prep.).

Psammophis ansorgii (Boulenger, 1905)
This snake is very poorly known. The type locality of the single type is vague ("Benguela to Bihe, Angola"), and the only subsequent material comprises six heads and one body from Bella-Vista (Hellmich, 1957). The Tundavala specimens (Fig. 7) are the first with detailed locality and habitat. They agree morphologically with the description and the plate provided in the original description (Boulenger, 1905), and its phylogenetic affinities within *Psammophis* are currently being addressed (Branch et al., in prep.).

Figure 7: Ansorge's whip snake (*Psammophis ansorgii*).

Eumecia anchietae Bocage, 1870
This serpentiform skink was described from "Huilla Plateau" (Bocage, 1870), and the Tundavala material can therefore be considered topotypic material and the first collected since the type description. The species has a curiously disjunct distribution, with isolated populations known from the Upemba Plateau, DRC, NW Zambia, northern Serengeti, etc. Various subspecies have been proposed (Laurent, 1964) but have never been reassessed within a modern, integrated taxonomic framework. Whether the species is a complex of cryptic, vicariant species remains unresolved and is the subject of ongoing research (Branch et al., in prep.).

Chamaeleo anchietae Bocage, 1872
Double-scaled chameleons from Tundavala (Fig. 8) correspond morphologically to

Figure 8: Double-scaled chameleon (*Chamaeleo anchietae*).

the original description (Bocage, 1872). As with *Eumecia anchietae,* this taxon was described from "Huilla" (Bocage, 1872) and also has similarly disjunct distribution (i.e., Marunga Plateau, Katanga, Kivu, DRC; Udzungwa Mountains, Tanzania). Various subspecies have been proposed (Laurent, 1952), but their status remains unresolved (possibly comprising a complex of cryptic, vicariant species) and is the subject of ongoing research (Branch et al., in prep.).

Trachylepis hoeschi (Mertens, 1954)
This fat terrestrial skink was found in montane grasslands, often near termite mounds in which it may shelter. It is endemic to Angola and Namibia, and previously known in Angola only from lowlands in Namibe province (Laurent, 1964; Haacke *unpub. data*; Branch *unpub. data*; Ceríaco *et al.*, 2016). This record constitutes an important range extension of the species onto the plateau, above 2200 m a.s.l.. Further studies will help reveal if the species is tolerant to altitudinal range, or if the upland population reflects cryptic speciation.

Figure 9: Hoesch's skink (*Trachylepis hoeschi*).

Although the Angolan escarpment has affinities with the adjoining biomes, it acts as a barrier between the drier coastal plains and the inland plateaus, allowing speciation to develop (Huntley, 1974), explaining the high level of endemism observed in the region (see Tab. 1 and Tab. 2). At least five of the recorded species consist of important rediscoveries of Angolan plateau endemics. *Psammophis ansorgii* and *Leptopelis anchietae* have not been recorded for 60 and 53 years, respectively, which is not a total surprise, given the lack of studies in Angola for decades as a consequence of the civil war and lack of zoologists. The specimens of *Psammophylax rhombeatus ocellatus, Chamaeleo anchietae,* and *Eumecia anchietae,* recorded recently (this study and Branch et al., unpub. data, and Vaz Pinto, pers. comm.), are the first for many decades in Angola. The type specimens for all of the species described by Bocage, were lost in the 1978 fire that burnt the Lisbon Museum, and thus the rediscovery of these species is critical for taxonomic studies and may facilitate the nomination of neotypes and the resolution of cryptic diversity within disjunct populations.

Conservation

The presence of a high number of endemic amphibians and reptiles in the Tundavala region, though the taxonomic status of many species remains unresolved, highlights the relevance and urgency of effective protection of the region. Further studies on the recorded species may reveal further cryptic diversity and thus amplify further the urgency for its protection. More comprehensive surveys in adjacent habitats will also likely increase the number of species recorded in the region.

In many respects, Tundavala represents only the tip of the iceberg when it comes to the immense and poorly known herpetological diversity of the Angolan escarpment. As Clark et al. (2011) have highlighted, further research and conservation are urgently needed. The study of the biogeography and herpetofauna of the rest of the Angolan escarpment is of high priority. Herpetological surveys in northern regions of the escarpment, such as Kwanza Sul and Kwanza Norte, have taken place and will be continued (Baptista et al., in prep.).

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