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Filling the gap: Noteworthy herpetological discoveries in North West Province, South Africa

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Abstract

The North West Province, South Africa, is centrally situated in southern Africa and is characterised by savannah with a mesic, temperate climate in the east and a hot, arid climate in the west. While the eastern region is fairly well-documented for herpetofauna, the arid central and western regions are poorly surveyed. Given that the Province has been targeted by the national government for development of infrastructure, the overall deficiency of biodiversity data could result in impact assessments that are not well-informed. We, therefore, carried out herpetofaunal surveys over two years (2019–2020) in the North West Province to improve knowledge on the distributions of reptiles and amphibians. Our surveys added a total of 578 new records to an earlier baseline of 1340 records. In addition, over 300 records were added to a citizen-science platform in connection with our surveys. As compared to the previous 100 years, our surveys increased the herpetofaunal dataset by 68% in just two years, increased geographic coverage by 20% and brought the total number of species with accurate records for the Province to 102 reptiles and 23 amphibians. We also recorded range extensions for five reptile species and confirmed the presence of *Dendroaspis polylepis* (Black Mamba) in the west where it had been last recorded in 1996. Our surveys resulted in a significant increase in biodiversity data for the Province and provided a better foundation for spatial planning that accounts for biodiversity and the maintenance of ecological function.

Key Words

Africa, amphibians, barcoding, biogeography, conservation, reptiles, spatial planning, species richness, surveys

Introduction

South Africa has a rich and diverse herpetofauna comprising approximately 33% of the reptile species and 11% of the amphibian species known from sub-Saharan Africa. These species assemblages include 401 native, extant (non-marine) reptile species of which 52% are endemic or near-endemic to the country (> 90% of their range in South Africa; Tolley et al. 2019) and 131 amphibians of which 63% are strictly endemic to South Africa (Minter et al. 2004; Measey et al. 2019). There have been two comprehensive atlassing projects for herpetofauna of the region (South Africa, Eswatini and Lesotho), which have greatly improved knowledge on species ecology and distributions (see Minter et al. 2004; Bates et al. 2014). Thus, compared to other parts of Africa, the herpetofauna of South Africa are well-documented in terms of distribution, endemism and richness patterns (see Tolley et al. 2016). These data show that the highest species richness in South Africa is centred in the north-eastern and south-western parts of the country, possibly due to topographic heterogeneity that provides varied habitats in both climate and substrate (Alexander et al. 2004) and that South African endemics are clustered in the south-west (see Minter et al. 2004; Alexander and Marais 2007).

Despite the relatively comprehensive herpetofaunal knowledge, there are several geographic areas in South Africa that stand out for their paucity of herpetological records (see Branch 2014). Noteworthy in this regard are the central and northern Karoo of the Western and Northern Cape Provinces (Holness et al. 2016; Telford et al. 2022), the central Eastern Cape Province and the western North West Province (see Bates et al. 2014). The scarcity of occurrence records from these parts of the country has resulted in a perception that they have relatively low species richness, particularly for reptiles (see Branch 2014). Of these areas, the North West Province has undergone significant habitat transformation (Fig. 1) primarily due to pastoral activities throughout the Province, with mining and urban expansion affecting the eastern parts of the Province (North West Department of Rural, Environment and Agricultural Development (READ) 2015; Skowno et al. 2021). Much of the western extent of the Province consists of arid Kalahari habitat which is comparatively intact, given the climate cannot support high densities of grazing ungulates, whether game or livestock (Fig. 1) and, thus, limits intensive farming activities. Therefore, the combined effect of comparatively few data and heavy habitat transformation across large parts of North West Province imperils the biodiversity of the Province.

The elevated risk to biodiversity is particularly germane given that the North West Province Development Plan – 2030 (North West Department of Rural, Environment and Agricultural Development (READ) 2015) and the South African National Development Plan (National Planning Commission 2012) call for the expansion of human settlements and the accompanying development of road, rail, water and electrical transmission infrastructure to support the projected increase in human population. These plans highlight the need for spatial planning to support appropriate land use decision-making, while the 'biodiversity sector plan' for the Province further indicates that spatial planning must be informed by foundational biodiversity data (North West Department of Rural, Environment and Agricultural Development (READ) 2015). Undeniably, ensuring service delivery for the urban and rural population does not consist only of augmenting man-made infrastructure, but also depends on preserving natural areas to retain their ecological function (North West Department of Rural, Environment and Agricultural Development (READ) 2015). Given that ecological services cannot be emulated artificially, protection of natural ecosystems is paramount.

Effective spatial planning and mapping of critical biodiversity areas must be based on underlying biological information, such as data on vegetation type, freshwater features and species occurrence records. While there is some existing knowledge on certain of these biological and environmental traits, the Province is not well surveyed for species occurrence, particularly for reptiles and amphibians (see Minter et al. 2004; Bates et al. 2014). Occurrence data for these taxa are needed to update the Province's biodiversity sector plan (see North West Department of Rural, Environment and Agricultural Development (READ) 2015), yet there have previously been no targeted surveys to generate the required data. Data from existing atlas projects (Minter et al. 2004; Bates et al. 2014), show that the majority of records from the Province are from the eastern parts, leaving the central and west comparatively under-sampled. Although some herpetofaunal records exist for the Province on publicly accessible databases (e.g. Minter et al. 2004; Bates et al. 2014; iNaturalist, ReptileMap and FrogMap – http://adu.org.za/), many of these records originate from historical collections and lack accuracy. However, these databases are the mainstay for biodiversity practitioners and spatial planners. Essentially, much of the readily available data are too coarse for the precise distribution mapping needed for land-use planning. Furthermore, a significant number of the records in the atlassing datasets are duplicates (original museum records are repeated in the published literature and then were logged as separate records), giving an inflated estimate of the number of unique records.

Overall, current knowledge suggests that species richness is highest along the eastern margin of the North West Province (Alexander and Marais 2007; Power and Verburgt 2014). However, the estimated richness can be biased by areas where sampling effort has been greatest (see Branch 2014) and the mapped richness pattern may, thus, be the result of uneven sampling rather than actual differences in species richness (e.g. Tolley et al. 2016). The North West Province is at the interface of sub-tropical environments extending from the north, as well as arid Kalahari environments to the west and mesic/temperate habitats from the east and south (Fig. 1). Much of the Province is covered by savannah and this biome is typically sub-divided into the Eastern Kalahari Bushveld and the Central Bushveld bioregions, with the grassland biome/ecoregion covering the south-eastern extent of the Province (fig. 1 in Power and Olivier 2019). There is a strong east-west climatic gradient across the Province, with a mesic, temperate climate in the east and a hot, arid climate in the west (fig. 1 in Mucina and Rutherford 2006; Cole et al. 2021) and these environmental factors could be influential in driving species richness patterns. Given that the Province is poorly surveyed for reptiles and amphibians, it is possible that the geographic ranges of some species have been underestimated and this would affect species richness estimates.

To improve knowledge of herpetofaunal diversity for North West Province, we carried out targeted surveys in the most poorly sampled regions of the Province, identified through interrogation of the historical data available on public databases. Using our new data, together with publicly available data of sufficient quality, we improved the quality of the species richness maps, record range ex-

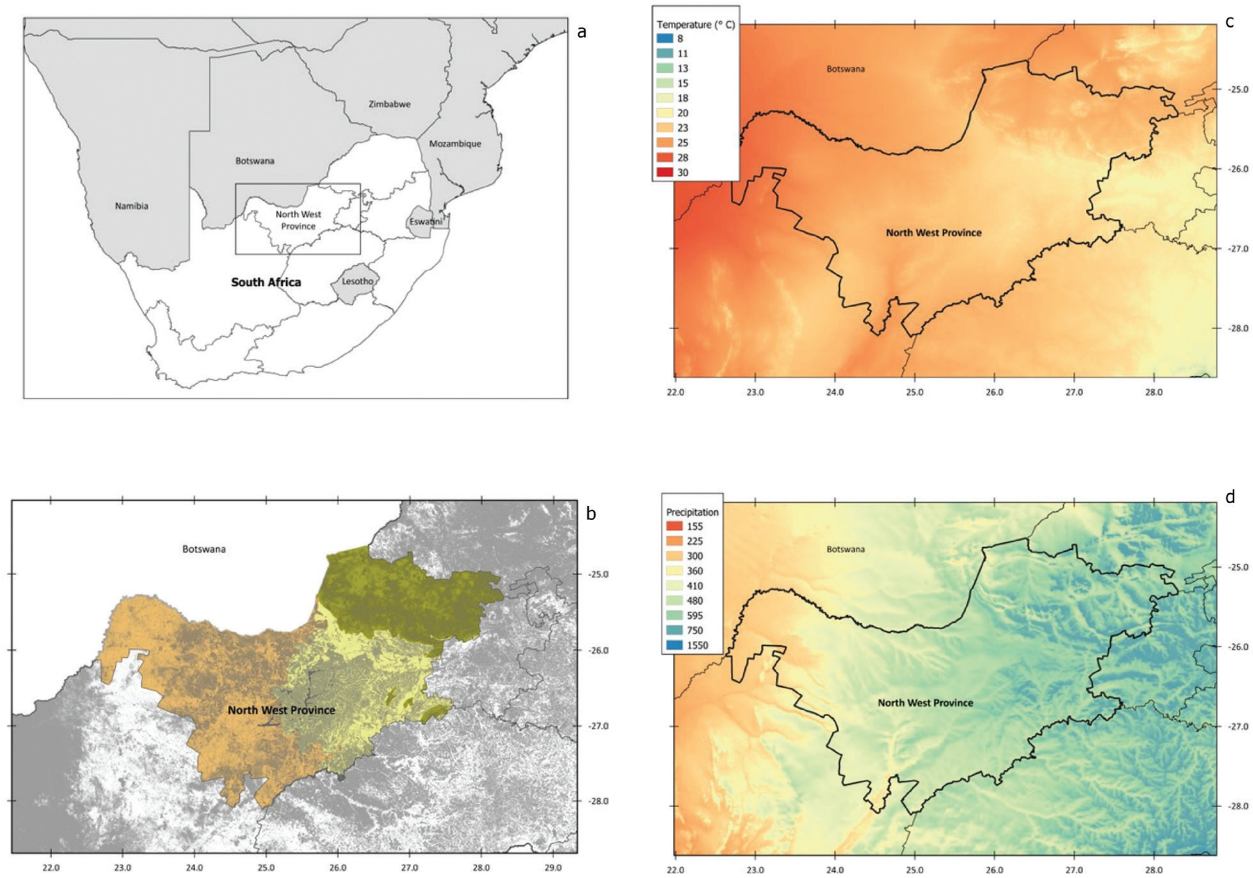

Figure 1. a. Location of North West Province, South Africa; **b.** Ecoregions (orange: western arid Kalahari, yellow: southern Highveld grassland, green: eastern mesic Bushveld, superimposed by the degree of habitat transformation as of 2019 (grey); **c.** Average temperature of warmest quarter (°C; bio10); **d.** Annual precipitation (mm/year; bio12). Environmental data from CHELSA (http://chelsa-climate.org/) and land cover data from South African Department of Forestry, Fisheries and Environment (https://egis.environment.gov.za/sa_national_land_cover_datasets). Polygons within South Africa show provincial borders.

tensions and generated a more comprehensive species list for the Province. We also provide new, publicly accessible data for North West Province which can be used for spatial planning.

Materials and methods

A pre-survey herpetofaunal dataset was assembled by gathering occurrence records from databases that were available on commonly accessed public databases prior to our surveys. These data were considered representative of the scope and type of data that would be readily available for spatial planning at that time. Databases accessed were iNaturalist (inaturalist.org, ReptileMap and FrogMap (http://vmus.adu.org.za/) for North West Province as of 31 December 2018. Data from ReptileMap and FrogMap partly consist of records collated and published by past atlassing projects, which included museum records and photographs contributed by citizen scientists (Minter et al. 2004; Bates et al. 2014). Therefore, these platforms include records of varying quality, but are representative of the actual data that would be readily available for spatial planning. Our intent was not to improve the quality of the historical records, but to utilise the same data that would likely be used by biodiversity practitioners. Given our study objectives, we did not attempt to georeference data of low precision/missing coordinates, nor attempt to confirm identifications of existing museum specimens or photos. The dataset was, however, updated for outdated taxonomy and checked for geographic coordinate errors as compared to locality descriptions. Notably, some of the historical FrogMap data were at quarter-degree grid square (QDS ~ 625 km^2) resolution only, although photographic records were available at higher resolution. Ultimately, the publicly available records were filtered to include only those with sufficiently precise locality data (geographic coordinates to at least one decimal place), while removing duplicate records (usually from the literature) and records where precision or accuracy was lacking (e.g. QDS precision or lower, obscured coordinates).

Species distribution maps were downloaded (as of 31 December 2018) from the IUCN Red List of Threatened Species (https://www.iucnredlist.org/) and the South African Species Status website (http://speciesstatus.sanbi.org/). These were used to create species richness maps in QGIS v.3.2 (QGIS 2022) by merging all map polygons. The merged layers were intersected with a fine resolution grid (5 minute × 5 minute coordinate grid – termed 'pentad') roughly 9 km × 9 km in size. To estimate species richness per grid cell, the number of distribution polygons intersecting with each cell was summed using QGIS v.3.2. Species richness maps for South African reptiles and amphibians were then created by depicting the counts of species per grid cell using a colour gradient.

We created a density map to show the spatial distribution of accurate records available for the Province. Therefore, all records that were only available at a low resolution (i.e. QDS or lower) were not included. Using the filtered and edited dataset, the density of species records was calculated in QGIS v.3.2 through the 'counts' analysis tool and done so separately for reptiles and amphibians to generate maps of existing sampling effort (i.e. record density). The density of accurate records was mapped to identify undersampled areas in the Province (Fig. 2). Taking into account the sampling gaps, but also habitat variation and logistical constraints, three main sites were then chosen for dedicated 10-day surveys (March 2019 in the north-west, October 2019 in the north-east, April 2020 in the south), which included active diurnal and nocturnal searching and the use of trap arrays (Fig. 2). An extra site was chosen for a brief five-day survey using only active searching (November 2020). At each main site, three trap arrays were set out consisting of Y-shaped fence lines with 10-m arms, along which six funnel traps and four pitfalls were set (after Maritz et al. 2007). For daytime active searches, two separate teams (three people per team) walked daily transects starting at the same location, but moving in different directions. Transect sites were chosen, based on habitat quality and ease of access. Each transect was timed, running for a minimum of two hours during the morning. Transects started when ambient temperature was at least 20 °C, but after two hours, searches were terminated if the ambient temperature exceeded 38 °C and if no records had been made for at least 30 minutes. In some cases, searches were continued for longer than two hours if the above conditions had not yet been met. For night-time active searches, two separate teams drove different routes at 30–35 km.hr^{-1} along asphalt and dirt roads, starting at dusk and lasting for up to three hours or until ambient temperatures dropped below 20 °C. Roads were scanned for any reptiles or amphibians.

Occurrence of reptiles and amphibians were recorded using GPS (~ 3 m precision) and DNA samples and/or voucher specimens were taken for a representative set of individuals. All voucher specimens were fixed in 10% formalin and transferred to 70% ethanol after 48 hours and DNA samples were preserved in NAP buffer. After processing, voucher specimens were deposited in the National Museum, Bloemfontein and DNA samples were deposited in the National Wildlife Biobank (South African National Biodiversity Institute, Pretoria).

Species identifications were made based on scalation and other morphological features using standard field guides for the region (e.g. Branch 1998; Marais 2011), including historical guides containing detailed information on morphology (FitzSimons 1943, 1962; Broadley 1990). The exclusive use of colouration and known distributions was avoided for making identifications (see Stephens et al. 2022). Some specimens recorded in the field could not be confidently identified to species level (n = 24), particularly in cases of species with weakly defined "diagnostic" traits that overlap with other species (see Stephens et al. 2022). Other unidentified records were represented by shed skins or severely damaged road-kill specimens. For these records, a tentative field identification was assigned at either species or genus level and this was followed up using a DNA barcoding approach to assign the final species identification. The choice of 'barcoding' gene varied, based on the available comparative sequence data on GenBank (mitochondrial: *16S*, *Cyt-b*, *ND4* and nuclear: *c-mos*). To carry out barcoding, tissues were dried in a vacuum centrifuge prior to DNA extraction. Total genomic DNA was extracted using a salt extraction protocol (Aljanabi and Martinez 1997). PCR amplification varied according to genes, using the following primer sets – *16S*: 16Sa and 16Sb (Palumbi et al. 2002); ND4: L4437 and H5540 (Macey et al. 1997) or ND4-F3 and ND4-R4 (Arévalo et al. 1994); *Cyt-b*: L14910 and H16064 (Burbrink et al. 2000); *c-mos*: CMOS-FUF and CMOS-FUR (Gamble et al. 2008). For all genes, an initial denaturation step was carried out for 4 min at 95 °C, followed by 35 cycles of denaturation (94 °C, 45 s), with annealing varying according to gene (51–58 °C, 45 s) and an extension (72 °C, 1 min). This was followed by a final extension at 72 °C for 10 min. PCR products were quantified by electrophoresis on 1% agarose gel. Sanger sequencing was carried out at Macrogen (Amsterdam, Netherlands) using the forward primers for each gene. Sequences were checked, edited and aligned in Geneious v.11.1.5 (https://www.geneious.com). Each sequence was then submitted to BLAST: Basic Local Alignment Search Tool (https://blast.ncbi.nlm.nih.gov/Blast.cgi) using the Geneious BLAST plug-in. For each sample, a 'similarity score' (percentage of DNA base-pair similarity) to existing sequences on GenBank was estimated using the BLAST Sequence Analysis Tool available at the NCBI (National Center for Biotechnology Information; https://www.ncbi.nlm.nih.gov/). Final identifications were made based on this similarity score, with scores close to 100% considered strong support for the identification. In two cases (*Psammophis* sp. and *Pelomedusa* sp.), the range of potential matches were not available on GenBank for the genes we sequenced. We, therefore, sequenced comparative material from the South African National Wildlife DNA Bank from potentially matching species (i.e. *Psammophis brevirostris*, *Pelomedusa galeata* and *Pelomedusa subrufa*).

New records were collated with the historical dataset to create a final dataset of all records for the Province that met our accuracy and precision criteria. Range extensions were identified as species recorded outside the existing known distributions from the IUCN (www.iucnredlist.org/), with additional guidance taken from maps in Bates et al. (2014) for reptiles and Minter et al. (2004) for amphibians.

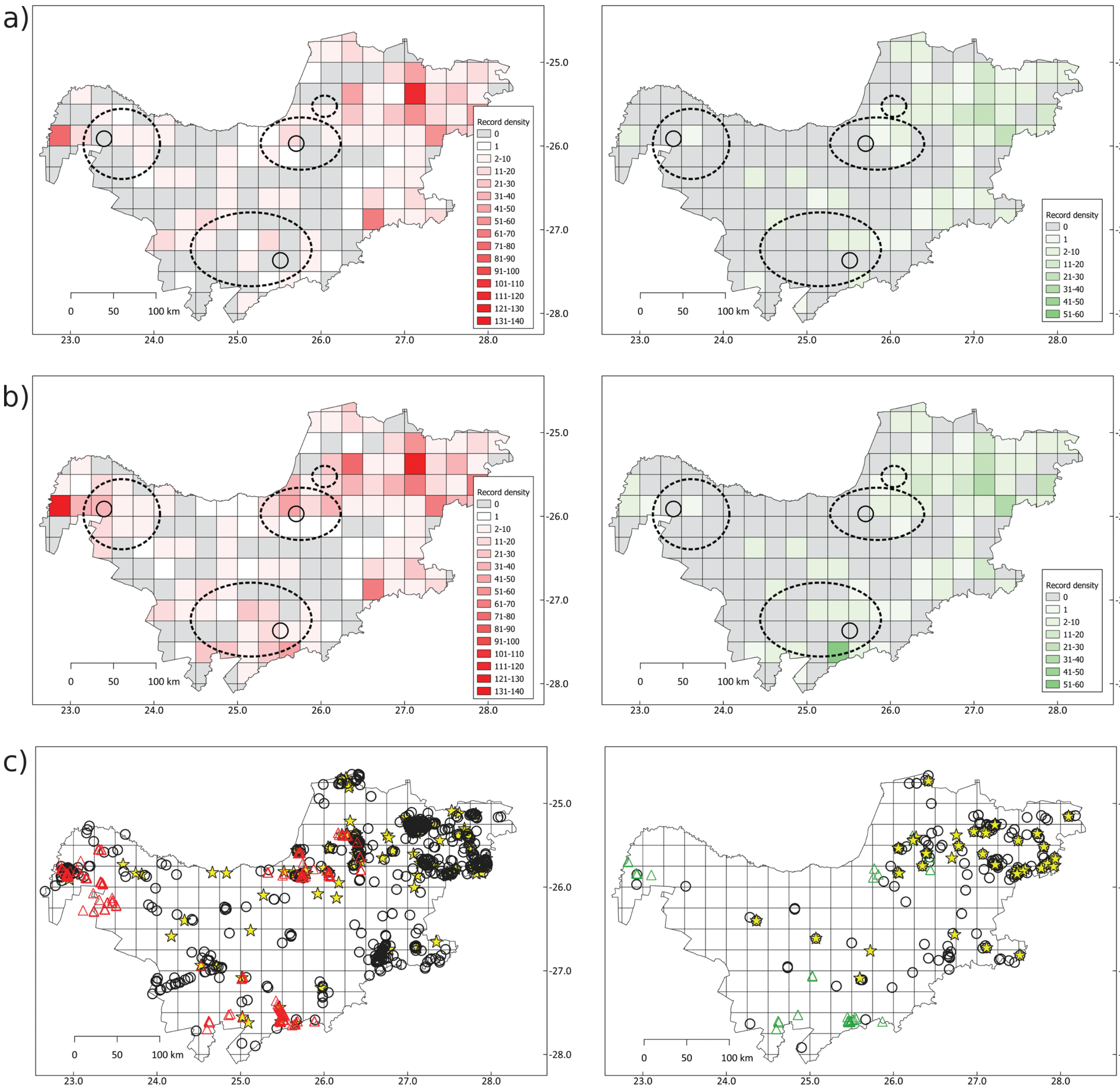

Figure 2. Density of reptile (left) and amphibian (right) species records for North West Province **a.** Prior to surveys; **b.** Total density including surveys; **c.** Accurate historical occurrence records (circles), new survey records (triangles) and new iNaturalist records (stars). The three main and one extra survey sites are shown by ellipses with broken outlines (smallest ellipse shows the site selected for the 5-day survey) with the trapping localities at the three main sites indicated by the open circles.

The final dataset was used to create new record density maps at the QDS resolution (for comparative purposes, at the same resolution as Minter et al. 2004 and Bates et al. 2014). Species distribution polygons were updated, incorporating new records to adjust the distribution polygons accordingly. The updated species map polygons were then intersected with the 9 × 9 km^2 pentad grid to produce final species richness maps for South African reptiles and amphibians.

Results

From the initial species richness mapping overlaying the distributions of individual species, we estimated that up to 115 reptile and 34 amphibian species are likely to occur in North West Province (Appendices 1, 2: Tables A1, A2). As of the end of 2018, the reptile and amphibian databases for North West Province had 1067 reptile and 273 amphibian records of acceptable quality (i.e. sufficiently precise localities; Table 1). These records included 94 of the 115 reptile and 22 of the 34 amphibian species predicted to occur in the Province (Appendices 1, 2: Tables A1, A2). The records were recorded in 104 of the 198 QDSs covering the Province (Fig. 2). Although 14 additional species (Amphibians: *Amietia fuscigula*, *Poyntonophrynus vertebralis*, *Pyxicephalus edulis*, *Vandijkophrynus gariepensis*; Reptiles: *Dalophia pistillum*, *Monopeltis infuscata*, *Karusasaurus polyzonus*, *Homoroselaps lacteus*, *Xenocalamus bicolor*, *Philothamnus hoplogaster*, *Leptotyphlops distanti*, *Leptotyphlops incognitus*, *Duberria lutrix*, *Psammobates*

Table 1. Number of records for existing (up to end of 2018) and new datasets (2019 through 2020) for reptiles and amphibians from the North West Province, South Africa. Existing data from the ReptileMap and FrogMap datasets excluded duplicate records and those that lacked adequate precision.

	Reptiles	Amphibians
Pre-survey		
ReptileMap/FrogMap	808	190
iNaturalist	259	52
Total pre-survey records	*1067*	*239*
New records		
North West survey	477	101
iNaturalist 2019–2020	210	109
Total new records	*687*	*210*
Total records	*1754*	*449*
% increase	64%	88%

oculifer) had been recorded from the Province (see Minter et al. 2004; Bates et al. 2014), these records have imprecise occurrence data (e.g. resolution at a QDS ca. 625 km^2). These were, therefore, not included in the initial density maps of 'accurate records', but they have been included in our species lists (dix 1: Appendix 1: Table A1).

For the 24 barcoded samples, all returned a high DNA sequence similarity score (i.e. > 96%) matching either sequences on GenBank or matching our additional sequenced material (Table 2). In total, the samples were identified as twelve different species. Ten of these were already present in the pre-existing provincial dataset (Anura: *Amietia delalandii*, *Amietia poyntoni*, *Tomopterna krugerensis*, *Tomopterna tandyi*; Squamata: *Agama atra*, *Hemidactylus mabouia*, *Trachylepis punctatissima*, *Naja nivea*, *Psammophis brevirostris*; Testudine: *Pelomedusa galeata*). There was also one newly-recorded species that was previously known from only one inaccurate record and had been considered possibly incorrect (Squamata: *Chondrodactylus bibronii*) and one invasive species (*Hemidactylus mabouia*). Furthermore, the tentative field identifications for four species were incorrect and two records were assigned only a genus level identification while in the field. The barcoding, however, allowed for a correct identification of these records to the species level (Table 2). Sequences of barcoded specimens were accessioned on GenBank (Table 2).

Overall, our field surveys added a total of 578 new records (477 reptile and 101 amphibian records) from 74 reptile and 20 amphibian species and these data have been deposited with the Global Biodiversity Information Facility (www.gbif.org) and are publicly available (https://doi.org/10.15468/v9y9p5). An additional 319 new records made by citizen scientists were deposited on iNaturalist, motivated by our interactions with North West Province citizenry (Table 1, Appendices 1, 2: Tables A1, A2). Altogether, the data represent a 68% increase in the herpetofaunal dataset for the Province. New records increased the provincial coverage to 124 of the 198 grid cells, representing an increased geographic coverage of approximately 20% (Fig. 2). The new records bring the total number of species with accurate and credible records to 102 reptile and 23 amphibian species for North West Province.

By comparing our records to the known geographic range for each species (i.e. Bates et al. 2014; see also https://www.iucnredlist.org/), we recorded range extensions for *Python natalensis* (~ 50 km), *Causus rhombeatus* (~ 100 km), *Chondrodactylus bibronii* (~ 100 km), *Elapsoidea sundevalii fitzsimonsi* (~ 250 km; Tolley et al. 2020) and confirmed the presence of *Dendroaspis polylepis* in the west of the Province, for which there had been a 200 km geographic gap in the existing records (Fig. 3). Our new records of *Chondrodactylus bibronii* confirm the occurrence of this species as an outlier from the main distribution (Bates et al. 2014; compare to specimen PEM R00344 collected in 1905). Our records come from a nearby region to that recently confirmed by Heinz et al. (2021) from the Northern Cape Province, suggesting the range of this species may have been underestimated historically and might still be underestimated. This resulted in our interpretation of the distribution map being extended to include the area from where these records were made. We also recorded a new, extra-limital locality for *Hemidactylus mabouia*, the identification of which was confirmed by the barcoding (Table 2). It is likely that this specimen was brought into Molopo Nature Reserve in a delivery of hay for animal feed (GJA, NST & KAT, pers. obs. 2019).

Our final dataset was used to create updated species richness maps for South African reptiles and amphibians using the same methods described above (Fig. 4) and to produce a species list for the Province (Appendices 1, 2: Tables A1, A2).

Discussion

Our targeted surveys in North West Province resulted in a substantial increase in the size of the provincial herpetofaunal dataset in comparison to accurate records collected over the previous 100 years – we increased the dataset by 68% in only two years. Our records were also of better quality than those in the pre-existing historical dataset, with more precise locality information and many voucher specimens that are linked to tissue samples. Our pre-survey analyses of record density allowed us to strategically target areas most in need of survey effort and to focus survey techniques to maximise the chance of recording species that had not previously been recorded in the surveyed areas. Thus, our records were almost all geographically unique, increasing their value and impact for regional planning and assessment of biodiversity. Our surveys revealed that several species are more widespread in North West Province than historical records indicated, resulting in the extension of several known ranges. Our comparative analysis of species richness also showed that estimates were influenced by sampling intensity, suggesting that further

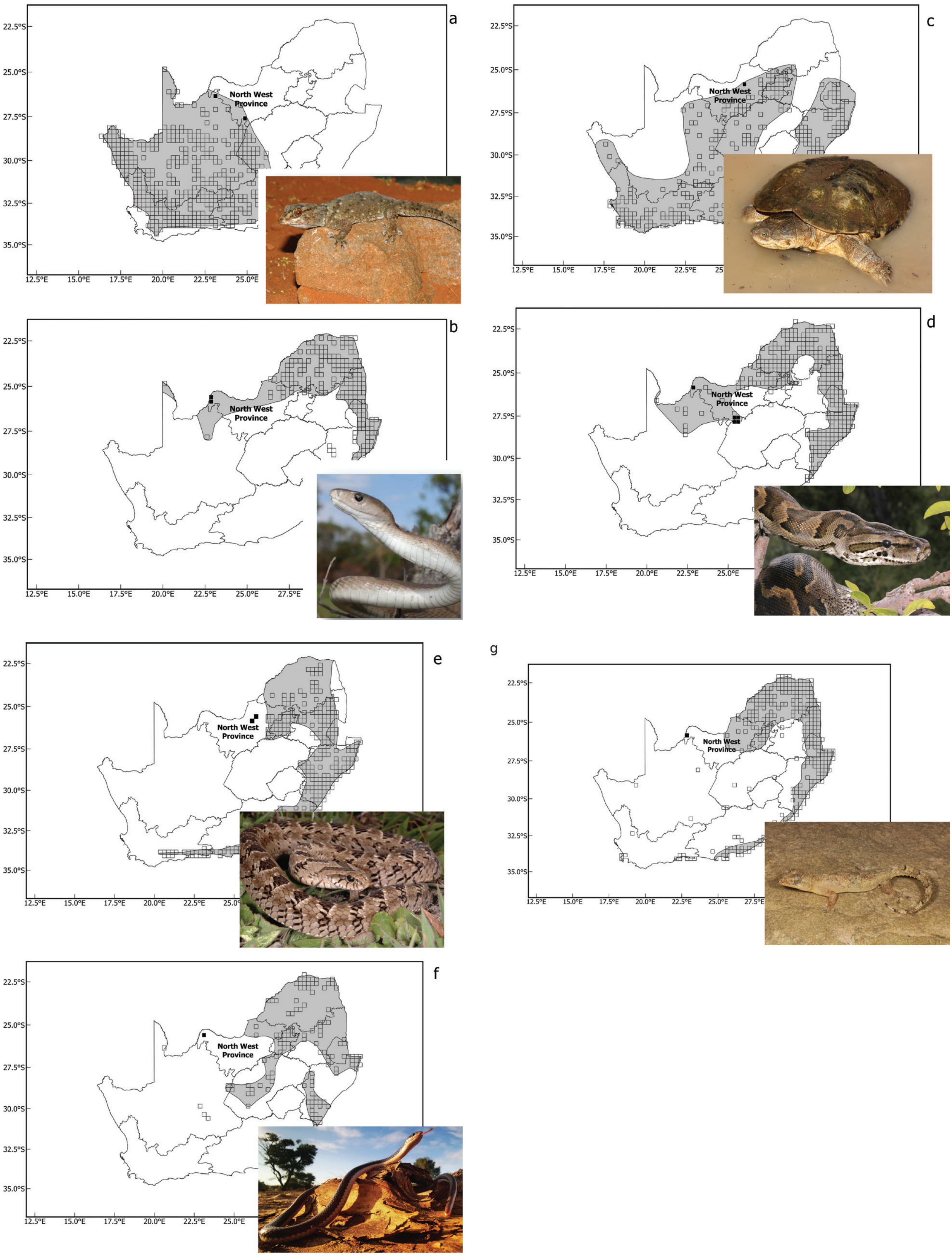

Figure 3. Currently inferred ranges of reptiles from South Africa where survey data confirm previously uncertain range edges for **a.** *Chondrodactylus bibronii*; **b.** *Dendroaspis polylepis*; extend previously inferred ranges for **c.** *Pelomedusa galeata*; **d.** *Python natalensis*; include new records that are outlying to the currently inferred range edge for **e.** *Causus rhombeatus*; **f.** *Elapsoidea sundevalli*; and represent a new extra-limital record for **g.** *Hemidactylus mabouia*. Black squares show the localities (at the quarter degree level) for new records that influence the known range extents, whereas the open squares show previously-existing records.

Table 2. Tentative field identifications that were confirmed or alternative identifications made through DNA barcoding. Provided in the columns are the field number, taxonomic information, GenBank accession numbers for each gene and the percentage sequence similarity to DNA sequences on GenBank given in parentheses. Dashes indicate genes not sequenced. Additional material sequenced for comparative purposes are also provided. Voucher specimen numbers are given where available (PEM: Port Elizabeth Museum, NMB: National Museum Bloemfontein). The species are ordered alphabetically by taxonomic hierarchy (by Order, Family and Genus/species).

Field #	Order	Family	Field ID	Barcoded ID	*16S*	*Cyt– b*	*ND4*	*c– mos*	Voucher
S1016	Anura	Pyxicephalidae	*Amietia delalandii*	*A. delalandii*	OP508237 (100)	–	–	–	–
M144	Anura	Pyxicephalidae	*Amietia delalandii*	*A. delalandii*	OP508236 (100)	–	–	–	–
T099A	Anura	Pyxicephalidae	*Amietia poyntoni*	*A. poyntoni*	OP508238 (100)	–	–	–	–
T099B	Anura	Pyxicephalidae	*Amietia poyntoni*	*A. poyntoni*	OP508239 (100)	–	–	–	–
T114	Anura	Pyxicephalidae	*Amietia poyntoni*	*A. delalandii*	OP508240 (99.8)	–	–	–	–
T115	Anura	Pyxicephalidae	*Amietia poyntoni*	*A. delalandii*	OP508241 (99.8)	–	–	–	–
S902	Anura	Pyxicephalidae	*Tomopterna cryptotis*	*T. krugerensis*	OP508720 (99.6)	–	–	–	–
N001	Anura	Pyxicephalidae	*Tomopterna* sp.	*T. tandyi*	OP50871 (99.8)	–	–	–	NMB A08209
T024	Anura	Pyxicephalidae	*Tomopterna* sp.	*T. tandyi*	OP508718 (99.8)	–	–	–	NMB A08257
T123	Anura	Pyxicephalidae	*Tomopterna* sp.	*T. tandyi*	OP508719 (99.8)	–	–	–	NMB A08255
T089	Squamata	Agamidae	*Agama* sp.	*A. atra*	OP508303 (99.4)	–	–	–	NMB R11946
T090	Squamata	Agamidae	*Agama* sp.	*A. atra*	OP508304 (99.4)	–	–	–	NMB R11947
M038	Squamata	Elapidae	*Naja nivea* (skin)	*N. nivea*	OP508307 (100)	–	–	–	–
S891	Squamata	Gekkonidae	*Chondrodactylus bibronii*	*C. bibronii*	OP508305 (96.2)	–	–	–	–
S941	Squamata	Gekkonidae	*Hemidactylus mabouia*	*H. mabouia*	OP508306 (96.6)	–	–	–	NMB R11828
KAT20-1	Squamata	Psammophiidae	*Psammophis brevirostris*	*P. brevirostris*	–	OP535022 (99.9)	OP535026 (99.9)	OP535017 (100)	–
N020	Squamata	Psammophiidae	*Psammophis brevirostris*	*P. brevirostris*	–	OP535023 (99.9)	OP535027 (99.9)	OP535018 (100)	NMB R11904
N061	Squamata	Psammophiidae	*Psammophis brevirostris*	*P. brevirostris*	–	–	OP535028 (99.7)	OP535019 (100)	NMB R11954
M041	Squamata	Scincidae	*Trachylepis spilogaster*	*T. punctatissima*	OP508516 (99.4)	–	–	–	NMB R11844
M047	Squamata	Scincidae	*Trachylepis spilogaster*	*T. punctatissima*	OP508517 (99.4)	–	–	–	–
S839	Squamata	Scincidae	*Trachylepis spilogaster*	*T. punctatissima*	OP508518 (99.6)	–	–	–	NMB R11807
S876	Squamata	Scincidae	*Trachylepis spilogaster*	*T. punctatissima*	OP508519 (99.6)	–	–	–	NMB R11839
S904	Squamata	Scincidae	*Trachylepis spilogaster*	*T. punctatissima*	OP508520 (99.6)	–	–	–	NMB R11820
M143	Testudines	Pelomedusidae	*Pelomedusa galeata*	*P. galeata*	OP508410 (100)	–	–	–	–
Additional material sequenced									
GAL10	Testudines	Pelomedusidae	*Pelomedusa galeata*	na	OP508410	–	–	–	–
HB048	Testudines	Pelomedusidae	*Pelomedusa galeata*	na	OP508411	–	–	–	–
MB 21424	Testudines	Pelomedusidae	*Pelomedusa galeata*	na	OP508412	–	–	–	–
MBUR 00553	Testudines	Pelomedusidae	*Pelomedusa galeata*	na	OP508413	–	–	–	–
MBUR 01266	Testudines	Pelomedusidae	*Pelomedusa galeata*	na	OP508414	–	–	–	–
RSP057	Testudines	Pelomedusidae	*Pelomedusa galeata*	na	OP508415	–	–	–	–
S594	Testudines	Pelomedusidae	*Pelomedusa galeata*	na	OP508416	–	–	–	–
TGE T3-8	Testudines	Pelomedusidae	*Pelomedusa galeata*	na	OP508417	–	–	– –	
WC-5833	Testudines	Pelomedusidae	*Pelomedusa galeata*	na	OP508418	–	–	–	PEM R23646
WP318	Testudines	Pelomedusidae	*Pelomedusa galeata*	na	OP508419	–	–	–	–
HB521	Testudines	Pelomedusidae	*Pelomedusa subrufa*	na	OP508420	–	–	–	–
MBUR 00238	Squamata	Psammophiidae	*Psammophis brevirostris*	na	–	OP535024	OP535029	OP535020	–
MBUR 01225	Squamata	Psammophiidae	*Psammophis brevirostris*	na	–	OP535025	OP535030	OP535021	–

surveys in the Province are needed. These findings highlight the importance of targeted biodiversity sampling in improving baseline occurrence datasets, which form the foundation for development plans and supporting conservation management (see Brooks et al. 2004; Collen et al. 2008; Hoveka et al. 2020; Hamilton et al. 2022).

Surprisingly, several of the range extensions recorded in our surveys were large-bodied species that would not be expected to go undetected in areas of occurrence and is further testament to how poorly the area has been surveyed to date. As with the range extensions for mammals (Power et al. 2019), most were recorded in the western parts of the Province in areas that we identified as particularly undersampled. Probably the most notable range extension detected in our surveys was for the Southern African Python, *Python natalensis*. We recorded this large-bodied and iconic species outside of its previously known range in the western and southern parts of the Province, with some new records indicating that the distribution also extends into adjacent parts of Free State Province in the vicinity of Bloemhof Nature Reserve and Sandveld Nature Reserve (ca. 27.64°S, 25.69°E). Given the notoriety of this species, it is difficult to accept that it has simply evaded detection in these areas in the past. Nevertheless, it does appear that records are still rather scant overall, although in recent years, there have been an increasing number of reports from the public to provincial conservation authorities regarding *P. natalensis* (RJ Power, Pers. Obs.). This could mean the species naturally occurs in low densities or these are observations of vagrants. Alternatively, the apparent increase in observations could indicate that *P. natalensis* is expanding its geographic range. Alexander (2007) showed that the distribution of *P. natalensis* is limited by environmental temperatures mainly due to limitations imposed on effective incubation of clutches by breeding females. It is, thus, possible that the range of this species has extended south into previously cooler areas in response to climatic warming. Given their comparable biogeographic affinities and similarities in the geographic boundaries of their distributions, expansion of ranges in North West Province due to climatic warming may also explain our findings of many new records for other snake species, as well as for some mammals (Power and Olivier 2019). For example, Black Mamba (*Dendroaspis polylepis*) and Common Night Adder (*Causus rhombeatus*) both have large ranges that extend into the tropical hot savannah of southern, eastern and west-central Africa (see Alexander and Marais 2007; Phelps 2010; Marques et al. 2018; Spawls et al. 2018; Chippaux and Jackson 2019; Pietersen et al. 2021). The possibility of south or westward range expansion of these snakes highlights another valuable function of targeted surveys in revealing the geographic dynamics of distributions of species. It is also possible that, in the future, similar changes will be detected on a bioregional scale, with significant implications for conservation planning and development.

Within the North West Province, the zoogeography has been broadly divided into three areas that generally correspond to defined ecological bioregions: the western arid Kalahari, eastern mesic Bushveld and southern Highveld grasslands based on mammals (Power and Olivier 2019). These areas also broadly correspond to the obvious east-west climatic gradient (Fig. 1, see also Cole et al. 2021). Previous work on mammals has shown that there is also a species richness gradient across the Province, with higher richness in the east, declining to the west (Power et al. 2019). Our findings show a similar gradient in species richness for the herpetofauna. However, the herpetofaunal species richness gradient is not entirely congruent with the ecoregions. Similar to mammals, the eastern mesic Bushveld ecoregion does have the highest species richness for both reptiles and amphibians, but species richness of the reptiles is also relatively high in southern Highveld grasslands and arid Kalahari (Figs 1, 4). This difference between mammals and reptiles may be the result of many species of reptiles being well-adapted to arid conditions. In contrast, the richness pattern for amphibians strongly matches that of the ecoregions, with a declining east-west richness gradient (Figs 1, 4), from the Central Bushveld to Highveld grasslands to arid Kalahari, that is similar to mammals (Power and Olivier 2019).

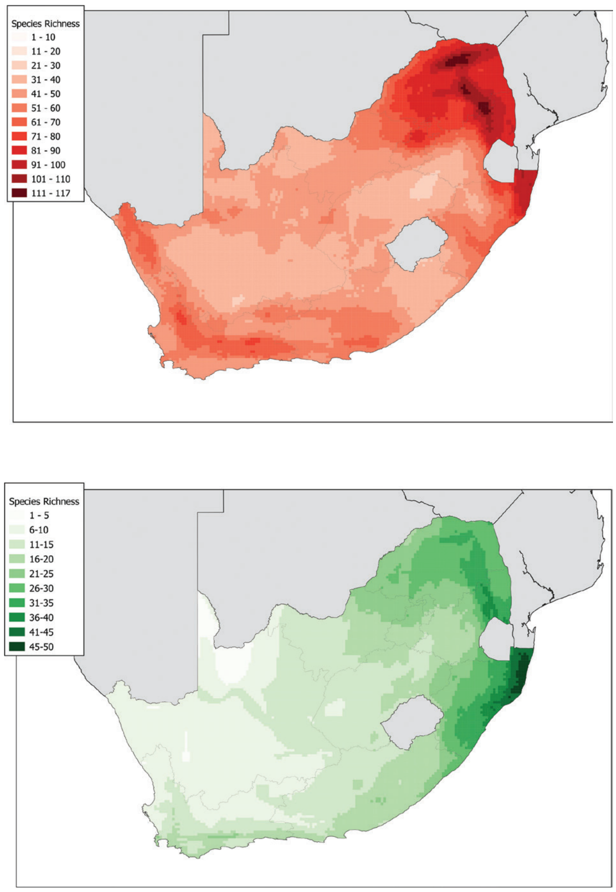

Figure 4. Species richness for **a.** Reptiles; **b.** Amphibians from South Africa.

Dissimilarity between the species richness patterns for mammals and reptiles demonstrates the limitations of relying on selected taxonomic groups as surrogates for biodiversity planning (Cox et al. 2022). At present, the biodiversity conservation plan for North West Province is biased towards the more comprehensive publicly accessible datasets of the mammals, birds and plants (North West Department of Rural, Environment and Agricultural Development (READ) 2015), a range of taxa that may not have adequately captured general biological patterns needed for regional planning. The additional focus on gathering data for reptiles and amphibians will, thus, contribute towards a more comprehensive approach for future provincial conservation plans that can conserve biodiversity more inclusively. While it is essential to collect basic biological and natural history data for development planning, the collection of long-term datasets consisting of accurate spatial distribution data have been undervalued historically (Greene 2005; Stroud and Thompson 2019; Miller et al. 2020; Travis 2020). As a result, exploratory surveys and collection of foundational data are typically under-funded as compared to hypothesis-driven research (Meineke et al. 2019; Miller et al. 2020), making such studies unappealing for research efforts, even though they are essential for identifying priority areas for conservation planning and areas critical for the protection of biodiversity. For example, targeted biological surveys in Mozambique (e.g. Conradie et al. 2016) have resulted in mountain inselbergs being identified as Key Biodiversity Areas (WCS, Governo de Moçambique and USAID 2021), clearly demonstrating the conservation value of basic survey data.

Several specimens collected during our surveys were difficult to identify with meaningful confidence required for biodiversity inventories. This was the result of the presence of several morphologically similar species occurring in the area (e.g. *Trachylepis* sp.: Stephens et al. 2022; *Amietia* sp.: Channing et al. 2016; *Tomopterna* sp.: Channing and du Preez 2020) and, in some cases, fragmentary evidence (e.g. specimens consisting of parts of shed skin or extensively damaged roadkill). We made use of barcoding to verify the identity of these specimens and resolved uncertainty of the specimen identity in all cases. Barcoding thus acts as a quality check for difficult identification and prevented the perpetuation of identifications of cryptic species being based on geographic location. We reiterate the views of Stephens et al. (2022) that the geographic location of a specimen should not be used as an identification attribute as this leads to the perpetuation of identification errors. Thus, we recommend that barcoding be incorporated as part of the standard protocols in future surveys, particularly for morphologically conservative species groups.

The dearth of records for even charismatic or notorious species might be sufficient to foster renewed interest in surveying North West Province. This need not be limited to *bona fide* scientific institutions and citizen scientists should be incentivised to inventory such areas (i.e. contributing to online platforms or BioBlitz projects; Parker et al. 2018). Our study greatly benefitted from our targeted engagements with citizens and clearly increased the number of records and species recorded from the Province and we strongly encourage this avenue of data collection. Indeed, there is an increasing reliance of citizen science-based distribution mapping (Tiago et al. 2017; Johnston et al. 2020). However, this approach does have some limitations in terms of accurate identifications, due to photos that may be inadequate to make confident identifications or confusion around morphologically conservative taxa. Our additional means of DNA barcoding for species identification emphasises the importance of professional scientists to be at the forefront, particularly so when highlighting the risks of overlooking certain species when only the phenotype is considered.

Conclusion

The significant impact of the data collected during our targeted surveys on the North West Province biodiversity database demonstrates the benefit of conducting targeted surveys for filling geographic gaps in species distribution data. Unfortunately, the recent trend of increasing levels of red tape relating to bureaucratic hurdles associated with the collection of biological data can severely impede progress (Alves et al. 2018; Friso et al. 2020; Alexander et al. 2021). We, thus, implore national and provincial authorities to cut bureaucracy and to facilitate the provision of *essential* permits. A reduction of red tape will provide a positive feedback loop, encouraging researchers to carry out biodiversity surveys that support the very same national and provincial authorities that issue these permits. Notwithstanding, the updated knowledge of the Province's herpetofauna makes a new and vital contribution when it comes to further iterations of the provincial and national biodiversity sector plans. Furthermore, there is a wealth of historical (i.e. museum) data that do not currently influence biodiversity planning. In addition, some of these data lack precision and/or accuracy making those sources less tractable. While beyond the scope of the present study, a concerted effort to make these records publicly available and to improve these records through georeferencing and/or consulting original literature or notes could provide an additional source of accurate records for biodiversity planning. Such data also would be extremely valuable for tracking distribution shifts or biodiversity losses over time and contribute greatly to IUCN Red List assessments, tracking long-term species assemblage shifts, as well as ground-truthing of climatic niche models. Thus, efforts should be made to incorporate both new survey data, as well as historical data to address current and future conservation goals.

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Appendix 1

Reptile species (listed by Order and Family) recorded from or presumed to occur in the North West Province, South Africa. Those with accurate records are indicated (X) for each time period (pre-survey years – through 2018 and survey years – 2019 & 2020). If indicated by a Q in the pre-survey column, there are records for the species, but only at the resolution of quarter-degree grid square (QDS). Distribution column indicates species (X) with IUCN distribution maps that intersect with the Province, although some have not been recorded from the Province. The species are indicated as endemic, near endemic (> 90% of range in South Africa) or not endemic to South Africa and the IUCN Red List assessment type (Global or Regional), threat category and threat criteria as of 2021 are given for each species. DD: Data Deficient, LC: Least Concern, VU: Vulnerable (no Endangered or Critically Endangered species occur in the North West Province).

Table A1. Reptile species (listed by Order and Family) recorded from or presumed to occur in the North West Province, South Africa.

Order	Family	Genus	Species	Pre-survey	Survey	Distribution	South African Occurrence	Assessment Type	Threat Category	Threat Criteria
Crocodylia										
	Crocodylidae	*Crocodylus*	*niloticus*	X	X	X	Not Endemic	Regional	VU	A2ac
Squamata-Lizard										
	Agamidae	*Acanthocercus*	*atricollis*	X	X	X	Not Endemic	Regional	LC	
	Agamidae	*Agama*	*aculeata*	X	X	X	Not Endemic	Regional	LC	
	Agamidae	*Agama*	*atra*	X	X	X	Near Endemic	Global	LC	
	Amphisbaenidae	*Dalophia*	*pistillum*	Q		X	Not Endemic	Regional	LC	
	Amphisbaenidae	*Monopeltis*	*capensis*	X		X	Near Endemic	Global	LC	
	Amphisbaenidae	*Monopeltis*	*infuscata*	Q		X	Not Endemic	Regional	LC	
	Amphisbaenidae	*Monopeltis*	*leonhardi*			X	Near Endemic	Global	LC	
	Amphisbaenidae	*Monopeltis*	*mauricei*	X		X	Not Endemic	Regional	LC	
	Amphisbaenidae	*Zygaspis*	*quadrifrons*	X		X	Not Endemic	Regional	LC	
	Chamaeleonidae	*Chamaeleo*	*dilepis*	X	X	X	Not Endemic	Regional	LC	
	Cordylidae	*Chamaesaura*	*aenea*			X	Near Endemic	Global	LC	
	Cordylidae	*Cordylus*	*jonesii*	X	X	X	Not Endemic	Regional	LC	
	Cordylidae	*Cordylus*	*vittifer*	X	X	X	Near Endemic	Global	LC	
	Cordylidae	*Karusasaurus*	*polyzonus*	Q		X	Near Endemic	Global	LC	
	Cordylidae	*Pseudocordylus*	*melanotus*			X	Near Endemic	Global	LC	
	Gekkonidae	*Chondrodactylus*	*bibronii*		X	X	Not Endemic	Regional	LC	
	Gekkonidae	*Chondrodactylus*	*turneri*	X	X	X	Not Endemic	Regional	LC	
	Gekkonidae	*Hemidactylus*	*mabouia*	X	X	X	Not Endemic	Regional	LC	
	Gekkonidae	*Homopholis*	*arnoldi*	X		X	Not Endemic	Regional	LC	
	Gekkonidae	*Lygodactylus*	*bradfieldi*	X		X	Not Endemic	Regional	LC	

Order	Family	Genus	Species	Pre-survey	Survey	Distribution	South African Occurrence	Assessment Type	Threat Category	Threat Criteria
Squamata-Lizard	Gekkonidae	*Lygodactylus*	*capensis*	X	X	X	Not Endemic	Regional	LC	
	Gekkonidae	*Lygodactylus*	*ocellatus*	X		X	Near Endemic	Global	LC	
	Gekkonidae	*Pachydactylus*	*affinis*	X	X	X	Endemic	Global	LC	
	Gekkonidae	*Pachydactylus*	*capensis*	X	X	X	Not Endemic	Regional	LC	
	Gekkonidae	*Pachydactylus*	*wahlbergii*	X	X	X	Not Endemic	Regional	LC	
	Gekkonidae	*Ptenopus*	*garrulus*	X	X	X	Not Endemic	Regional	LC	
	Gerrhosauridae	*Gerrhosaurus*	*flavigularis*	X	X	X	Not Endemic	Regional	LC	
	Lacertidae	*Heliobolus*	*lugubris*	X		X	Not Endemic	Regional	LC	
	Lacertidae	*Ichnotropis*	*capensis*	X		X	Not Endemic	Regional	LC	
	Lacertidae	*Meroles*	*squamulosus*	X	X	X	Not Endemic	Regional	LC	
	Lacertidae	*Nucras*	*holubi*	X	X	X	Not Endemic	Regional	LC	
	Lacertidae	*Nucras*	*intertexta*	X	X	X	Not Endemic	Regional	LC	
	Lacertidae	*Nucras*	*lalandii*	X		X	Near Endemic	Global	LC	
	Lacertidae	*Nucras*	*ornata*	X		X	Not Endemic	Regional	LC	
	Lacertidae	*Pedioplanis*	*lineoocellata*	X	X	X	Not Endemic	Regional	LC	
	Lacertidae	*Pedioplanis*	*namaquensis*	X	X	X	Not Endemic	Regional	LC	
	Scincidae	*Acontias*	*gracilicauda*	X	X	X	Near endemic	Global	LC	
	Scincidae	*Acontias*	*kgalagadi*	X		X	Not Endemic	Regional	LC	
	Scincidae	*Acontias*	*occidentalis*	X		X	Not Endemic	Regional	LC	
	Scincidae	*Mochlus*	*sundevallii*	X	X	X	Not Endemic	Regional	LC	
	Scincidae	*Panaspis*	*wahlbergii*	X	X	X	Not Endemic	Regional	LC	
	Scincidae	*Trachylepis*	*capensis*	X	X	X	Not Endemic	Regional	LC	
	Scincidae	*Trachylepis*	*damarana*		X	X	Not Endemic	Regional	LC	
	Scincidae	*Trachylepis*	*laevigata*		X	X	Endemic	Global	LC	
	Scincidae	*Trachylepis*	*occidentalis*	X	X	X	Not Endemic	Regional	LC	
	Scincidae	*Trachylepis*	*punctatissima*	X	X	X	Not Endemic	Regional	LC	
	Scincidae	*Trachylepis*	*punctulata*	X	X	X	Not Endemic	Regional	LC	
	Scincidae	*Trachylepis*	*spilogaster*	X	X	X	Not Endemic	Regional	LC	
	Scincidae	*Trachylepis*	*sulcata*			X	Not Endemic	Regional	LC	
	Scincidae	*Trachylepis*	*varia*	X	X	X	Not Endemic	Regional	LC	
	Scincidae	*Trachylepis*	*variegata*	X	X	X	Not Endemic	Regional	LC	
	Varanidae	*Varanus*	*albigularis*	X	X	X	Not Endemic	Regional	LC	
	Varanidae	*Varanus*	*niloticus*	X	X	X	Not Endemic	Regional	LC	
Squamata-Snake	Atractaspididae	*Amblyodipsas*	*polylepis*	X	X	X	Not Endemic	Regional	LC	
	Atractaspididae	*Amblyodipsas*	*ventrimaculata*			X	Not Endemic	Regional	LC	
	Atractaspididae	*Aparallactus*	*capensis*	X	X	X	Not Endemic	Regional	LC	
	Atractaspididae	*Atractaspis*	*bibronii*	X	X	X	Not Endemic	Regional	LC	
	Atractaspididae	*Atractaspis*	*duerdeni*	X		X	Not Endemic	Regional	LC	
	Atractaspididae	*Homoroselaps*	*lacteus*	Q		X	Near Endemic	Global	LC	
	Atractaspididae	*Xenocalamus*	*bicolor*	Q		X	Not Endemic	Regional	LC	
	Colubridae	*Crotaphopeltis*	*hotamboeia*	X	X	X	Not Endemic	Regional	LC	
	Colubridae	*Dasypeltis*	*scabra*	X	X	X	Not Endemic	Regional	LC	
	Colubridae	*Dispholidus*	*typus*	X	X	X	Not Endemic	Regional	LC	
	Colubridae	*Philothamnus*	*hoplogaster*	Q		X	Not Endemic	Regional	LC	
	Colubridae	*Philothamnus*	*occidentalis*	X	X	X	Near Endemic	Global	LC	
	Colubridae	*Philothamnus*	*semivariegatus*	X	X	X	Not Endemic	Regional	LC	
	Colubridae	*Telescopus*	*semiannulatus*	X	X	X	Not Endemic	Regional	LC	
	Colubridae	*Thelotornis*	*capensis*	X		X	Not Endemic	Regional	LC	
	Elapidae	*Aspidelaps*	*scutatus*	X	X	X	Not Endemic	Regional	LC	
	Elapidae	*Dendroaspis*	*polylepis*	X	X	X	Not Endemic	Regional	LC	
	Elapidae	*Elapsoidea*	*boulengeri*	X		X	Not Endemic	Regional	LC	
	Elapidae	*Elapsoidea*	*sundevallii*	X	X	X	Not Endemic	Regional	LC	
	Elapidae	*Hemachatus*	*haemachatus*	X		X	Near Endemic	Global	LC	
	Elapidae	*Naja*	*annulifera*	X	X	X	Not Endemic	Regional	LC	
	Elapidae	*Naja*	*mossambica*	X	X	X	Not Endemic	Regional	LC	
	Elapidae	*Naja*	*nivea*	X	X	X	Not Endemic	Regional	LC	
	Lamprophiidae	*Boaedon*	*capensis*	X	X	X	Not Endemic	Regional	LC	
	Lamprophiidae	*Gracililima*	*nyassae*		X	X	Not Endemic	Regional	LC	
	Lamprophiidae	*Lamprophis*	*aurora*	X		X	Near Endemic	Global	LC	
	Lamprophiidae	*Limaformosa*	*capensis*	X		X	Not Endemic	Regional	LC	
	Lamprophiidae	*Lycodonomorphus*	*inornatus*			X	Near Endemic	Global	LC	
	Lamprophiidae	*Lycodonomorphus*	*laevissimus*	X		X	Near Endemic	Global	LC	
	Lamprophiidae	*Lycodonomorphus*	*rufulus*	X		X	Not Endemic	Regional	LC	
	Lamprophiidae	*Lycophidion*	*capense*	X	X	X	Not Endemic	Regional	LC	
	Prosymnidae	*Prosymna*	*bivittata*	X		X	Not Endemic	Regional	LC	
	Prosymnidae	*Prosymna*	*sundevallii*	X		X	Near Endemic	Global	LC	
	Leptotyphlopidae	*Leptotyphlops*	*distanti*	Q		X	Near Endemic	Global	LC	

Order	Family	Genus	Species	Pre-survey	Survey	Distribution	South African Occurrence	Assessment Type	Threat Category	Threat Criteria
Squamata-Snake	Leptotyphlopidae	*Leptotyphlops*	*incognitus*	Q		X	Not Endemic	Regional	LC	
	Leptotyphlopidae	*Leptotyphlops*	*scutifrons*	X		X	Not Endemic	Regional	LC	
	Psammophiidae	*Dipsina*	*multimaculata*			X	Not Endemic	Regional	LC	
	Psammophiidae	*Psammophis*	*angolensis*	X	X	X	Not Endemic	Regional	LC	
	Psammophiidae	*Psammophis*	*brevirostris*	X	X	X	Not Endemic	Regional	LC	
	Psammophiidae	*Psammophis*	*crucifer*			X	Near Endemic	Global	LC	
	Psammophiidae	*Psammophis*	*leightoni*	X	X	X	Not Endemic	Regional	LC	
	Psammophiidae	*Psammophis*	*subtaeniatus*	X	X	X	Not Endemic	Regional	LC	
	Psammophiidae	*Psammophylax*	*rhombeatus*	X		X	Near Endemic	Global	LC	
	Psammophiidae	*Psammophylax*	*tritaeniatus*	X	X	X	Not Endemic	Regional	LC	
	Pseudaspididae	*Pseudaspis*	*cana*	X	X	X	Not Endemic	Regional	LC	
	Pseudoxyrhophiidae	*Duberria*	*lutrix*	Q		X	Not Endemic	Regional	LC	
	Pythonidae	*Python*	*natalensis*	X	X	X	Not Endemic	Regional	LC	
	Typhlopidae	*Afrotyphlops*	*bibronii*	X		X	Not Endemic	Regional	LC	
	Typhlopidae	*Rhinotyphlops*	*lalandei*	X	X	X	Not Endemic	Regional	LC	
	Viperidae	*Bitis*	*arietans*	X	X	X	Not Endemic	Regional	LC	
	Viperidae	*Bitis*	*caudalis*	X	X	X	Not Endemic	Regional	LC	
	Viperidae	*Causus*	*defilippii*			X	Not Endemic	Regional	LC	
	Viperidae	*Causus*	*rhombeatus*	X	X	X	Not Endemic	Regional	LC	
Testudines										
	Pelomedusidae	*Pelomedusa*	*galeata*	X	X	X	Near Endemic	Global	LC	
	Pelomedusidae	*Pelusios*	*sinuatus*	X	X	X	Not Endemic	Regional	LC	
	Testudinidae	*Homopus*	*femoralis*	X		X	Endemic	Global	LC	
	Testudinidae	*Kinixys*	*lobatsiana*	X	X	X	Near Endemic	Global	VU	A4cde
	Testudinidae	*Kinixys*	*spekii*	Q		X	Not Endemic	Regional	LC	
	Testudinidae	*Psammobates*	*oculifer*	X	X	X	Not Endemic	Regional	LC	
	Testudinidae	*Stigmochelys*	*pardalis*	X	X	X	Not Endemic	Regional	LC	

Appendix 2

Amphibian species (listed by Family) recorded from or presumed to occur in the North West Province, South Africa. Those with accurate records are indicated (X) for each time period (pre-survey years – through 2018 and survey years – 2019 & 2020). If indicated by a Q in the pre-survey column, there are records for that species, but only at the less precise quarter-degree level and these records were not included in the mapping datasets. Mapping column indicates species (X) which are presumed to occur in the Province given their overall distribution, but have not yet been recorded. The species are indicated as endemic, near endemic (> 90% of range in South Africa) or not endemic to South Africa and the IUCN Red List assessment type (Global or Regional), threat category as of 2021 are given for each species. LC: Least Concern, NE: Not Evaluated (No Critically Endangered, Endangered, Vulnerable or Near Threatened amphibians occur in the North West Province).

Table A2. Amphibian species (listed by Family) recorded from or presumed to occur in the North West Province, South Africa.

Order	Family	Genus	Species	Pre-survey	Survey	Distribution	South African Occurrence	Assessment Type	Threat Category
Anura	Bufonidae	*Poyntonophrynus*	*fenoulheti*	X	X	X	Not Endemic	Global	LC
Anura	Bufonidae	*Poyntonophrynus*	*vertebralis*	Q		X	Endemic	Global	LC
Anura	Bufonidae	*Schismaderma*	*carens*	X	X	X	Not Endemic	Global	LC
Anura	Bufonidae	*Sclerophrys*	*capensis*	X	X	X	Endemic	Global	LC
Anura	Bufonidae	*Sclerophrys*	*garmani*	X	X	X	Not Endemic	Global	LC
Anura	Bufonidae	*Sclerophrys*	*gutturalis*	X	X	X	Not Endemic	Global	LC
Anura	Bufonidae	*Sclerophrys*	*poweri*	X	X	X	Not Endemic	Global	LC
Anura	Bufonidae	*Sclerophrys*	*pusilla*			X	Not Endemic	Global	LC
Anura	Bufonidae	*Vandijkophrynus*	*gariepensis*	Q		X	Near Endemic	Global	LC
Anura	Hemisotidae	*Hemisus*	*marmoratus*			X	Not Endemic	Global	LC
Anura	Hyperoliidae	*Hyperolius*	*marmoratus*			X	Not Endemic	Global	LC
Anura	Hyperoliidae	*Kassina*	*senegalensis*	X	X	X	Not Endemic	Global	LC
Anura	Hyperoliidae	*Semnodactylus*	*wealii*			X	Not Endemic	Global	LC
Anura	Brevicpetidae	*Breviceps*	*adspersus*	X	X	X	Not Endemic	Global	LC
Anura	Microhylidae	*Phrynomantis*	*bifasciatus*	X	X	X	Not Endemic	Global	LC
Anura	Phrynobatrachidae	*Phrynobatrachus*	*natalensis*	X		X	Not Endemic	Global	LC
Anura	Pipidae	*Xenopus*	*laevis*	X	X	X	Not Endemic	Global	LC
Anura	Ptychadenidae	*Hildebrandtia*	*ornata*			X	Not Endemic	Global	LC
Anura	Ptychadenidae	*Ptychadena*	*porosissima*			X	Not Endemic	Global	LC
Anura	Pyxicephalidae	*Amietia*	*delalandii*	X	X	X	Not Endemic	Global	LC

Order	Family	Genus	Species	Pre-survey	Survey	Distribution	South African Occurrence	Assessment Type	Threat Category
Anura	Pyxicephalidae	*Amietia*	*fuscigula*	Q		X	Endemic	Global	LC
Anura	Pyxicephalidae	*Amietia*	*poyntoni*	X	X	X	Not Endemic	Global	LC
Anura	Pyxicephalidae	*Pyxicephalus*	*edulis*	Q		X	Not Endemic	Global	LC
Anura	Pyxicephalidae	*Strongylopus*	*grayii*			X	Near Endemic	Global	LC
Anura	Pyxicephalidae	*Tomopterna*	*adiastola*			X	Not Endemic	Not Evaluated	NE
Anura	Pyxicephalidae	*Tomopterna*	*krugerensis*	X	X	X	Not Endemic	Global	LC
Anura	Pyxicephalidae	*Tomopterna*	*tandyi*	X	X	X	Not Endemic	Global	LC
Anura	Pyxicephalidae	*Cacosternum*	*boettgeri*	X	X	X	Not Endemic	Global	LC
Anura	Ptychadenidae	*Ptychadena*	*anchietae*	X	X	X	Not Endemic	Global	LC
Anura	Ptychadenidae	*Ptychadena*	*mossambica*	X		X	Not Endemic	Global	LC
Anura	Pyxicephalidae	*Pyxicephalus*	*adspersus*	X	X	X	Not Endemic	Global	LC
Anura	Pyxicephalidae	*Strongylopus*	*fasciatus*	X		X	Not Endemic	Global	LC
Anura	Pyxicephalidae	*Tomopterna*	*natalensis*	X	X	X	Near Endemic	Global	LC
Anura	Rhacophoridae	*Chiromantis*	*xerampelina*	X	X	X	Not Endemic	Global	LC