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Frog and reptile conservation through the lens of South Africa's nature-based cultural practices

Fortunate M Phaka [a,b,c], Jean Hugé [b,d,e], Maarten PM Vanhove [b] and Louis H du Preez [a,c]

[a]African Amphibian Conservation Research Group, Unit for Environmental Sciences and Management, North-West University, South Africa; [b]Hasselt University, Centre for Environmental Sciences, Research Group Zoology: Biodiversity and Toxicology, Diepenbeek, Belgium; [c]South African Institute for Aquatic Biodiversity, Makhanda, South Africa; [d]Department of Environmental Sciences, Faculty of Science, Open University of the Netherlands, Heerlen, the Netherlands; [e]Biology Department, Vrije Universiteit Brussel, Brussels, Belgium

ABSTRACT

Ethnoherpetology improves our understanding of the conservation implications of nature-based cultural practices through investigations of the influence of traditional culture on frog and reptile species (herptiles). Improved understanding of the implications of human activities on these taxa is especially important as herptiles are experiencing global population declines. Furthermore, improved understanding of nature-based cultural practices can better inform conservation planning that includes cultural practices as defined by South African legislation. The herptile-based cultural practices recorded from a sample of 275 online questionnaire respondents and 68 publications show some cultural practices to compel or inspire protection of herptiles. Conversely, other practices were found to pose a conservation risk as they either involve killing herptile species or they perpetuate negative perceptions towards them. Leveraging protective cultural practices as a conservation tool and mitigating culture-motivated threats requires integrating cultural aspects into modern law. Such an integrative approach is possible under South African legislation's provisions for socially inclusive conservation planning and recognition of customary law. Integrative conservation approaches are also in line with international policy such as the Kunming-Montreal global biodiversity framework. In addition to an inventory of herptile-based cultural practices, the study also assesses their feasibility as conservation tools. Furthermore, this study highlights a need for quantification of their conservation implications (both positive and negative) and aligning protective traditional cultural practices with modern means of law enforcement.

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CONTACT FM Phaka mafetap@gmail.com

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Introduction

People develop ways of interacting with local biodiversity over time through various traditional cultural practices (Shepard 1996; Alves 2012). These nature-based cultural practices include consumption of wild meat, use of wildlife in traditional remedies, and spiritual symbolism of animals (Kameri-Mbote 2002; Kothari 2007; Sifuna 2012; Phaka 2020; Ingram et al. 2021). Understanding the complexity of the interactions between people's cultures and wildlife as signified by nature-based cultural practices involves multiple disciplines bridged by ethnozoology (Alves and Albuquerque 2017). Ethnozoology is a hybrid of social and natural sciences that focuses on past and present relationships between animals and people's cultures (Alves and Souto 2015; Alves 2017). Ethnozoological investigations have the potential to inform conservation planning by contributing towards a balance between social and conservation objectives (Gavin et al. 2015; Alves and Albuquerque 2017).

A subfield of ethnozoology that investigates cultures' influence on frogs and reptiles (herpetofauna/herptiles) known as ethnoherpetology (Linares-Rosas et al. 2021), contributes to herptile conservation by improving the understanding of how human activities impact herptile populations (Alves et al. 2013) as conservation in any cultural landscape requires an understanding of cultures (IPBES 2018). Considering that herptile populations are experiencing some of the worst global declines due to human-related impacts (Collins and Storfer 2003; Hof et al. 2011; IUCN 2023), understanding the conservation implications of cultural practices (as part of human activities) is important. In addition to their potential threat to biodiversity, nature-based cultural practices are also the basis of communities' traditional ecological knowledge which can inform sustainable management practices (Poole 2018), as some cultural practices prevent overexploitation of the environment regardless of their premise not being modern environmental conservation policy (Allison 2017). South African legislation recognises that cultural practices in general can be used as customary law (i.e., enforceable rules developed from communities' cultural practices) with the same standing as common law (Republic of South Africa 1988; 1996) and has specific provisions for inclusion of cultural practices in conservation planning (Republic of South Africa 1998; Department of Environment, Forestry and Fisheries 2015).

South Africa's Constitution (Republic of South Africa 1996) and the Law of Evidence Amendment Act (Republic of South Africa 1988) provide the basis for the use of general cultural practices as customary law. South African courts can use customary law if it is readily accessible, has well-established rules and can be used in conjunction with common law (Republic of South Africa 1988). Traditional leaders have the authority to deal with matters arising in a community that observes a system of customary law (Republic of South Africa 1996). For conservation matters specifically, the National Environmental Management Act 107 of 1998 (NEMA) which is an overarching conservation framework (Republic of South Africa 1998) and the 2015 National Biodiversity Strategy and Action Plan (NBSAP) which aims to fulfil the objectives of the Convention on Biological Diversity in South Africa (Department of Environment, Forestry and Fisheries 2015), make provisions for cultural practices to be acknowledged and incorporated into wildlife conservation processes. Additionally, there is international policy to which South Africa is a signatory that promotes consideration of cultural practices as doing so

would contribute towards Sustainable Development Goals (United Nations 2015), be in line with the Convention on Biological Diversity's Global Biodiversity Framework targets (Convention on Biological Diversity 2022) and be an acknowledgement of Indigenous people's cultural heritage (United Nations 2007).

South Africa's diverse nature-based cultural practices (Department of Environment, Forestry and Fisheries 2015) and legislative environment make the country ideal for an ethnoherpetological study aimed at understanding the conservation implications of such practices. Once their conservation implications are understood, the country's legislation aimed at being culturally inclusive provides an opportunity to explore the feasibility of incorporating cultural practices into conservation planning. Here we present an ethnoherpetology study aimed at informing herptile conservation with an improved understanding of the challenges and prospects arising from South Africa's nature-based cultural practices. Furthermore, the study considers how the conservation prospects of nature-based cultural practices can be incorporated into inclusive conservation planning as envisaged by the country's legislation.

Materials and MethodS

We collected data on the herptile-based cultural practices of nine South African indigenous cultures (cultures of African origin) using a multilingual online questionnaire between 9 May 2020 and 9 May 2022, and by reviewing existing literature. The reviewed literature is from multiple fields including herpetology, anthropology, linguistics, agricultural sciences, meteorology and archaeology. The online questionnaire was used to collect data for multiple studies (including the current study) conducted as part of a doctoral research project (Phaka 2022) and was accessible in nine of South Africa's official indigenous languages.

The questionnaire's landing page provided full details of this research and participants could only proceed to the questions after confirming they understood the details (Supplementary Material 1). This questionnaire used a semi-structured approach with a combination of targeted questions and open-ended questions about herptile species whose photographs were embedded in the questionnaire. Targeted questions were about names, use and cultural importance of the pictured herptile species. Open-ended questions requested respondents to provide any additional information about how their culture relates to herptiles. This questionnaire was promoted, using paid advertisements, to South African social media users who used indigenous language and showed interest in wildlife (as determined by social media sites' algorithms) on Twitter (www.twitter.com/wild_vernac), Facebook (www.facebook.com/wildvernac), and Instagram (www.instagram.com/wild_vernac).

We reviewed existing literature using the snowball sampling technique which started with a 'herpetology' and 'South Africa' search query on Google Scholar to find publications that mention both keywords in their text. Snowball sampling involves identifying relevant literature and searching its reference lists for additional literature that meets the inclusion criteria (Collaboration for Environmental Evidence 2013). Screening literature involved reading their contents to identify relevant publications (containing details of herptile-based cultural practices) for inclusion in this study's sample. We focused on the first page of search results as those that are most likely to be relevant

to a search query according to Google Scholar rankings (https://scholar.google.com/intl/en/scholar/about.html).

The nature-based cultural practices documented from the questionnaire and existing literature were coded and categorised according to prevailing themes into elements of culture (i.e., similarities in cultural practices emerging from the collected data) and their likely conservation implications. We created a conservation customary law framework to assess whether cultural practices that compel wildlife protection could be suitable for wildlife conservation under South Africa's customary law provision (Figure 1). This framework is based on the South African Constitution's (Republic of South Africa 1996) and Law of Evidence Amendment Act's (Republic of South Africa 1988) recognition that cultural practices which are accessible, established, enforceable and complement common law form customary law which has equal status as common law (Figure 1).

Study sample

A total of 68 publications were reviewed (cited in-text and listed in Supplementary Material 2). The online questionnaire had 275 respondents (Figure 2) belonging to nine indigenous cultural groups (according to South Africa's official population grouping based on language): AmaNdebele, AmaXhosa, AmaZulu, BaPedi, BaSotho, BaTswana, MaSwati, VaTsonga, and VhaVenda. The respondents were aged between 25 and 57 years, and 193 indicated they were male and 82 female.

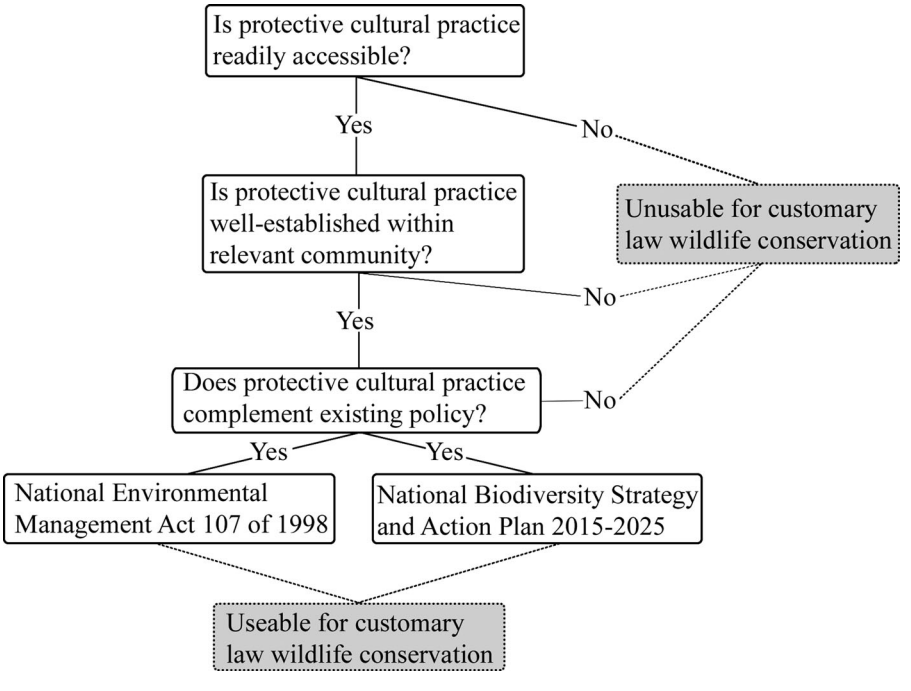

Figure 1. Conservation customary law framework for assessing whether protective nature-based cultural practices can be used for wildlife conservation according to South African government's recognition of customary law.

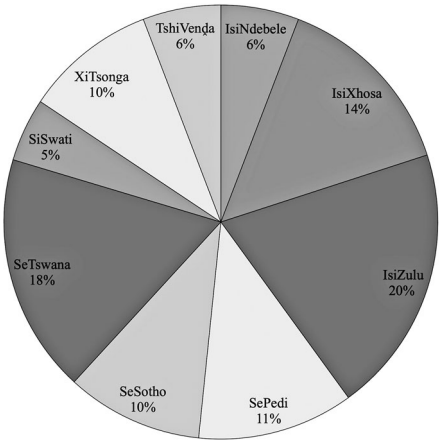

Figure 2. Respondents to a questionnaire about South Africa's herptile-based cultural practices grouped according to their culture.

Results

The herptile-based cultural practices documented from this study's sample are organised into ten elements of culture based on their prevailing theme. Figure 3 provides an overview of these elements and Table 1 provides details of practices categorised under each element. These elements of culture overlap in their general conservation implications (e.g., some are lethal while others are non-lethal when perceptions they perpetuate are not taken into consideration) and they also overlap in the basis of their categorisation (e.g., the folk tales and taxonomy are both based on observation of herptiles species' traits). Less prominent overlaps that are not annotated on Figure 3 include the overlap between gastronomy and taxonomy; herpetofauna that people eat are likely to have distinct Indigenous names but some herpetofauna will still have distinct indigenous names regardless of their gastronomic value.

The listing of cultural practices in Table 1 highlights their conservation implications as per Figure 3 categorisation. Among those herptiles being killed for nature-based cultural practices, there are four species of high conservation priority; Critically Endangered *Eretmochelys imbricata* (Hawksbill Turtle), Vulnerable *Kinixys natalensis* (Natal Hingeback Tortoise), Vulnerable *Smaug giganteus* (Sungazer) (IUCN 2023), and *Pyxicephalus adspersus* (Giant Bullfrog) which is included in the list of protected species issued in terms of South Africa's National Environmental Management: Biodiversity Act (Republic of South Africa 2004). Some practices are not directly lethal and a direct link to a negative conservation implication cannot be made, but they perpetuate negative perceptions that might lead to persecution (for example through the association of some herptiles with deception and evil in folk tales). Among the cultural practices that are protective of herptiles, there is totemism which attaches kinship to reptiles such as *Crocodylus niloticus* (Nile Crocodile) and prohibits their harm, and practices categorised as symbolism which consider *Breviceps* spp. (Rain Frogs) as harbingers of rain thus their presence is embraced.

Table 2 demonstrates the outcomes of assessing protective herptile-based cultural practices through a conservation customary law framework (Figure 1) to understand whether they are likely to be useable for wildlife conservation under South Africa's

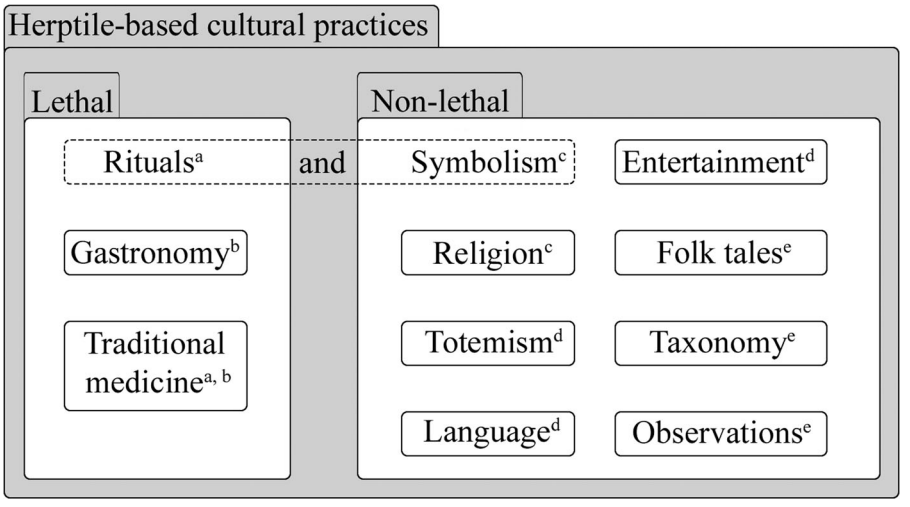

Figure 3. Categorisation of South Africa's herptile-based cultural practices into elements of culture based on their similarities emerging from the collected data (adapted from Phaka 2023). Overlaps in elements of culture: [a]magico-medicinal value; [b]ingestion of herptile tissue; [c]magico-religious value; [d]symbolic value; and [e]interpretation of observed traits.

customary law provisions. Among the recorded cultural practices that compel protection of wildlife there is deification of a serpentine river-dwelling creature which leads to riverine ecosystems being treated as sacred grounds thus minimising their disturbance (Table 2). Furthermore, the killing of herpetofauna that are considered rain symbols or totems is taboo, and having herpetofauna as symbols of heroism in poems or portraying other desirable traits in folk tales can reduce negative perceptions about them. The conservation customary law framework (Figure 1) demonstrates that nature-based cultural practices that are protective towards herpetofauna correspond with some NEMA National Environmental Management Principles (Republic of South Africa 1998) and NBSAP Strategic Objectives (Department of Environment, Forestry and Fisheries 2015).

Discussion

This ethnoherpetological study inventoried and analysed South Africa's herptile-based cultural practices to increase understanding of their conservation prospects and challenges. Furthermore, a framework is provided that can be used for conservation planning that incorporates protective nature-based cultural practices. Framing interactions between wildlife and people's cultures within the context of conservation helps realise the potential of ethnozoological investigations to inform conservation as discussed in previous research including Gavin et al. (2015), and Alves and Albuquerque (2017).

Categorising nature-based cultural practices into elements of culture based on their prevailing themes makes it possible to view (at a glance) the likely conservation implication of a certain practice (Figure 3), but this categorisation does have overlaps. These overlaps can lead to some practices being categorised differently within the elements of culture depending on an author's interpretation of prevailing themes or similarities

Table 1. South Africa's herptile-based cultural practices organised into different elements of culture. The inclusion criteria for each element of culture are shown in brackets. Within each element of culture, herpetofauna are organised according to taxonomic order.

1. Gastronomy (Ingestion of herptiles for protein)

Anura: *Pyxicephalus* species (Bullfrogs) are opportunistically hunted and eaten in Zulu, Pedi and Tsonga cultures (Du Preez and Cook, 2004; Phaka et al., 2017; Questionnaire*).

Crocodylia: *Crocodylus niloticus* are opportunistically hunted and eaten in Ndebele, Pedi, and Zulu cultures (Questionnaire*).

Squamata: *Python natalensis* (Southern African Python) are opportunistically hunted and eaten in Pedi culture (Questionnaire*).

Testudines: *Stigmochelys pardalis* (Leopard Tortoise) are opportunistically hunted and eaten in Pedi and Tsonga cultures (Anthony and Bellinger, 2007; Questionnaire*). Unspecified tortoise species opportunistically hunted and eaten in Eastern Cape Province (Van Zyl, 2020).

2. Traditional medicine (Use of herptiles to remedy illness)

Anura: *Pyxicephalus adspersus* (Giant Bullfrogs) are used as medicine in Sotho culture (Du Preez, 1996). *Schismaderma carens* (African Red Toad) are used in the traditional medicine of undetermined South African cultures (Whiting et al., 2011).

Crocodylia: *Crocodylus niloticus* is used in traditional medicine (Whiting et al., 2011).

Squamata: *Lamprophis aurora* (Aurora House Snake), *Dendroaspis polylepis* (Black Mamba), *Dispholidus typus* (Boomslang), *Naja melanoleuca* (Central African Forest Cobra), *Chamaeleo dilepis* (Flap-necked Chameleon), *Acontias plumbeus* (Giant Legless Skink), *Dendroaspis angusticeps* (Green Mamba), *Naja mossambica* (Mozambique Spitting Cobra), *Pseudaspis cana* (Mole Snake), *Varanus niloticus* (Nile Monitor), *Psammophis phillipsii* (Olive Grass Snake), *Bitis arietans* (Puff Adder), *Hemachatus haemachatus* (Rinkhals), *Varanus albigularis* (Rock Monitor), *Broadleysaurus major* (Rough-scaled Plated Lizard), *P. natalensis*, *Acanthocercus atricollis* (Southern Tree Agama), *Naja annulifera* (Snouted Cobra), *Psammophylax rhombeatus* (Spotted Skaapsketer), *Psammophylax tritaeniatus* (Striped Skaapsketer), *Smaug giganteus* (Sungazer), *Cordylus vittifer* (Transvaal Girdled Lizard), *Cordylus tropidosternum* (Tropical Girdled Lizard), *Smaug warren* (Warren's Girdled Lizard), *Thelotornis capensis* (Vine Snake), and *Gerrhosaurus flavigularis* (Yellow-throated Plated Lizard) are used in the traditional medicine of undetermined South African cultures (Cunningham and Zondi, 1991; Cunningham, 1993; Simelane, 1996; Simelane and Kerley, 1997; Simelane and Kerley, 1998; Ngwenya, 2001; Whiting et al., 2011; Nieman et al., 2019). Night Adders (*Causus* spp.), and Water Snakes (*Lycodonomorphus* spp.) are used as medicine specifically in Zulu culture (Donda, 1997).

Testudines: *Chersina angulate* (Angulate Tortoise), *Kinixys belliana* (Bell's Hingeback Tortoise), *Eretmochelys imbricata* (Hawksbill Turtle), *S. pardalis*, *Kinixys natalensis* (Natal Hingeback Tortoise), and *Kinixys spekii* (Speke's Hingeback Tortoise) are used in the traditional medicine of undetermined South African cultures (Whiting et al., 2011).

3. Rituals and Symbolism (Herptiles symbolising desirable traits or phenomena)

Anura: Rain Frogs symbolise rain in Venḓa culture and harming them is forbidden (Mutshinyalo and Siebert, 2010). Clawed Frogs (*Xenopus* spp.) symbolise fertility in KhoiSan cultures (Thorp, 2013, 2015). Unspecified frog species were sacrificed for rain control rituals of Sotho cultures and unnamed South African Hunter-gatherer communities (Riep, 2011; Brunton et al., 2013). Unspecified frog species symbolise rain in KhoiSan cultures and harming them is forbidden (Potgieter, 1955; Bleek, 1933a, 1933b; Lewis-Williams and Pearce, 2004).

Crocodylia: *Crocodylus niloticus* are rain symbols in Pedi culture and harming them is forbidden (Lekgothoane and van Warmelo, 1938).

Squamata: *Varanus niloticus* carcasses are used for rain control rituals in Tswana culture, but it is forbidden to harm living individuals (Smith et al., 1975). *Python natalensis* are generally considered a symbol of wealth and power (Questionnaire*), while they also symbolise sexuality, knowledge and transition and harming them is forbidden in Tswana culture (Kenalemang and Kaya, 2012; Mandillah and Ekosse, 2018). *Python natalensis* and *V. niloticus* are sacrificed for rain control rituals in Zulu culture (Krige, 1950). Unspecified lizard, snake, and turtle species are sacrificed for rain control rituals in Hunter-gatherer and Sotho cultures (Riep, 2011; Brunton et al., 2013). Unspecified snake and tortoise species symbolise rain in KhoiSan cultures and harming them is forbidden (Potgieter, 1955; Bleek, 1933a, 1933b; Lewis-Williams and Pearce, 2004).

Testudines: Unspecified tortoise species symbolise rain in KhoiSan cultures and harming them is forbidden (Lewis-Williams and Pearce, 2004).

Herptiles in general: Aquatic herptiles symbolise the sanctity of waterbodies in Venḓa culture (Questionnaire*).

4. Religion (Worship or divinisation of herptiles)

Anura: Unspecified frog species are messengers from ancestors or deities and harming them is forbidden in Cape Nguni culture (Hirst 1991).

Squamata: *Python natalensis, V. niloticus*, *Boaedon capensis* (Brown House Snake), and unspecified chameleon species are regarded as messengers from ancestors or deities and harming them is forbidden (Hirst, 1991; Donda, 1997; Simelane and Kerley, 1997; Bernard, 2003, Letsoalo, 2009; Mutshinyalo and Siebert, 2010). Unspecified snake species are believed to be river-dwelling deities by various South African cultures (Hirst, 1991; Hoff, 1997; Bernard, 2003; Riep, 2011; Kenalemang and Kaya, 2012).

5. Totemism (Attaching kinship to herptiles)

Crocodylia: *Crocodylus niloticus* are totem animals for many South African clans including Bakwena, Bakoena, and Ngwenya (Malungana, 1994; Bongela, 2001; Tšiu, 2006; Riep, 2011; Koma, 2012; Graham, 2016; Pooley, 2016; Thwala, 2018).

Squamata: *Pseudaspis cana* are totem animals for the IsiXhosa speaking Majola clan (Bongela, 2001).
Testudines: Unspecified tortoise species are the totem animals for some BaPedi clans (Van Zyl, 1941; Maahlamela, 2017).
6. Languages (Use of herptiles in figures of speech)
Herptiles in general: Unspecified frog and reptile species are generally used in riddles, expressions, euphemisms, and similes of various languages (Blacking, 1961; Mathumba, 1988; Kgoroeadira, 1993; Donda, 1997; Thwala, 2017; Thwala, 2019).
7. Entertainment (Herptiles in traditional forms of entertainment)
Anura: Unspecified frog species feature in folk songs (Johnston, 1973; Nemukovhani, 1977).
Crocodylia: *Crocodylus niloticus* symbolises human qualities in the poetry of various cultures (Kgoroeadira, 1993).
Squamata: Unspecified skink, and snake species represent human qualities in the poetry of various cultures (Lekgothoane and van Warmelo, 1938; Van Zyl, 1941; Kgoroeadira, 1993; Malungana, 1994; Mamabolo, 1995; Groenewald, 1998).
8. Folk tales (Myths, superstitions, and stories in a culture's oral traditions)
Anura: Toads (*Sclerophrys* spp.) are said to attract lightning in Zulu culture (Questionnaire*). Unspecified frog species portray shape-shifting characters (Callaway, 1868).
Squamata: *Dendroaspis polylepis* and *P. natalensis* portray powerful traditional healers in Tsonga and Zulu cultures (Mavikane, 1990; Koopman, 2015). *Hemidactylus mabouia* (Tropical House Gecko) are said to be purveyors of evil spirits and have an incurable bite wound in Pedi and Tswana cultures (Questionnaire*). Unspecified chameleon and skink species portray messengers, or contrasts between punctuality (skink) and tardiness (chameleon) (Canonici, 1990; Mogapi, 1990). Unspecified snake species are said to kill people that disregard taboos and this tale is used to reinforce cultural taboos (Ngubane, 1977; Sinthumule and Mashau, 2020). Unspecified snake species portray deceptive characters in Tsonga culture (Mavikane, 1990).
9. Taxonomy (Naming and classification relating to herptiles)
Anura and reptiles: South Africa's traditional cultures have their own systems for naming and classification of herpetofauna (Phaka et al., 2019; Questionnaire*).
Crocodylia: The Indigenous language names for *C. niloticus* are used as a surname (e.g., Mokwena, Mokoena, Ngwenya, and Nghwenya) by various cultures (Kgoroeadira, 1993; Ndimande, 1998; Futhwa, 2011; Koma, 2012; Thwala, 2018). Kwena (*C. niloticus*) is a given name in Pedi culture (Questionnaire*). Crocodiles are used in the names of places: Mokgalakwena – fierce crocodile (originates from SePedi).
Squamata: *Bitis arietans* is used as a placename for Keiskamma River which means Puff Adder River in this word (Keiskamma) originating from Khoekhoen languages (Raper, 2018). Nsuze, a word meaning snake in IsiZulu, is used as a name for a place (Questionnaire*). The generic term for a snake (nyoka) is a given name in Ndebele and Zulu culture (Ngubane 2000; Skhosana 2005).
Testudines: Unspecified tortoise species are used as a placename for Nakop which means tortoise place in this word originating from Khoekhoen languages (Raper, 2018).
10. Observations (Animal observations interpreted using Indigenous knowledge)
Anura: *Pyxicephalus* species rain from the sky during thunderstorms according to Tsonga culture (Questionnaire*). Clawed frogs rain from the sky during thunderstorms according to Zulu culture (Phaka et al., 2019). Grass Frogs (*Ptychadena* spp.) and other unspecified frog species are said to bring rain when their activity increases according to Zulu culture (Basdew et al., 2017; Phaka et al., 2019; Vilakazi et al., 2019).
Squamata: Increased activity of unspecified snake species signal onset of spring (Zuma-Netshiukhwi et al., 2013).
Testudines: Increased activity of unspecified tortoise species signal onset of spring (Zuma-Netshiukhwi et al., 2013).

*Data obtained from this study's online questionnaire.

in a community's cultural practices. However, the categorisation of cultural practices based on their conservation implications is less likely to change as practices can uniformly be categorised as lethal or non-lethal regardless of which elements of culture they are interpreted to belong to.

In addition to conforming with the provisions of NEMA for consideration of all forms of knowledge in conservation planning (Republic of South Africa 1998) and NBSAP strategic objectives, which encourage the adoption of practices that sustain biodiversity benefits (Department of Environment, Forestry and Fisheries 2015), integrating cultural practices into conservation planning is also relevant to international policy. Such consideration would contribute towards the realisation of Sustainable Development Goals (SDG 11, 15 and 16) by promoting conservation planning that is inclusive of previously excluded members of society, while also documenting (and incidentally) protecting cultural practices (United Nations 2015). Such culturally inclusive biodiversity conservation is also in line with the Global Biodiversity Framework (Target 22) which calls for consideration of cultural practices in decision-making (Convention on Biological Diversity 2022).

Table 2. Matching protective cultural practices to South African conservation policy.

Nature-based cultural practice	Potential conservation benefit	Relevant conservation policy
Deification of serpentine river-dwelling creature. Riverine ecosystems are sacred and thus avoided out of respect/fear.	Riverine habitat avoidance minimises pollution and disturbance of a sensitive ecosystem.	• NEMA Principle 4ai (Ecosystem disturbances to be minimised or avoided).
People consider themselves to have kinship with their totem animal species. Cultural norms compel/inspire protection of animals considered part of a familial clan.	Totemism instils an attitude of care towards the totem animal and the habitat it requires for survival.	• NEMA Principle 4ai (Ecosystem disturbances to be minimised or avoided). • NEMA Principle 4 g (Decisions must recognise all forms of knowledge).
Herptiles that symbolise rain should not be killed (especially during rainy/mating season), and the presence of species considered to be ancestral messengers is embraced.	Protection of herptile populations by preventing interruption of mating and reducing human/wildlife impacts.	• NEMA Principle 4 g (Decisions must recognise all forms of knowledge). • NBSAP Strategic Objective 6 (Effective knowledge base, including Indigenous knowledge, to support conservation).
Some herpetofauna symbolise various desirable traits, such as heroism, wisdom, and traditional healing ability.	Creates awareness of herpetofauna and attaches positive perceptions to them.	• NEMA Principle 4f and 4 h (Raising environmental awareness empowers communities and promotes meaningful participation in conservation).
Farmers use the activity patterns of herptiles as rainfall indicators, so they know when to start sowing.	Using natural cues to reduce dependence on municipal water infrastructure and maximise crop yield by sowing when climatic conditions afford the best chance of a successful harvest.	• NEMA Principle 4 g (Decisions must recognise all forms of knowledge). • NBSAP Strategic Objective 6 (Effective knowledge foundation, including Indigenous knowledge, to support conservation).

Furthermore, Indigenous people's cultural heritage and the right of people to maintain their traditional cultural practices is acknowledged by the United Nations Declaration on the Rights of Indigenous Peoples Protection (United Nations 2007), thus cultural practices should not be overlooked in conservation planning.

Conservation prospects of herptile-based cultural practices

It is possible to draw parallels between protective cultural practices and conservation policy and these parallels serve to highlight where cultural practices can potentially be incorporated into conservation planning (Table 2). Finding common ground for biodiversity conservation between cultural practices and modern law is made easier when a country's legislation formally recognises customary law as is the case with South Africa. Cultural practices have been acknowledged as having a potential role to play in conservation planning by existing herpetological (Simelane and Kerley 1997) and traditional ecological knowledge (Chibememe et al. 2014) research. African communities historically learned nature's instrumental and spiritual value from a young age, while rules and taboos were used to govern their relationship with nature (Mashige 2011). Some taboos are accompanied by myths that are meant to prevent people from disregarding those taboos, and an example of this is the forest areas that are sacred in Venḓa culture which are also protected from overexploitation by the myth of a deadly snake patrolling those areas (Sinthumule and Mashau 2020). Taboos and myths have similarities to South African environmental legislation's precautionary principle, in that they discourage use to avoid overexploitation of sacred natural areas. Boundaries to exploitation of nature are also established through totemism (Mashige 2011) by compelling clan

members to protect their totem animal species and incidentally its habitat through attachment of kinship to that species.

Another cultural practice that has the potential to protect wildlife and is common across South African cultures is the deification of a serpentine, river-dwelling creature that leads to minimised disturbance of riverine ecosystems (Table 2). *Python natalensis* (Southern African Python) and *Varanus niloticus* (Nile Monitor) are associated with deities and ancestors in most South African cultures, thus providing the possibility for these two species to be flagship species (species chosen as representatives for conservation issues due to the desirable traits people associate with them (Veríssimo et al. 2011)). Revered species have the potential to be flagships (Simelane and Kerley 1997), to stimulate conservation action to the benefit of their ecosystems (Meffe and Carroll 1997). Besides using reverence as a reason to protect animals, their value to traditional health practitioners could serve as motivation to conserve them (Simelane and Kerley 1998), when those practitioners are sensitised to the conservation issues of their valued animal species. The benefits that people derive from biodiversity (IPBES 2018) generally can serve as justifications for biodiversity conservation (Millennium Ecosystem Assessment 2005). Approaches that combine protective cultural practices with modern policy are possible, as demonstrated by the collaborative efforts between Burundese researchers and traditional health practitioners to promote fair and equal benefit sharing of genetic resources (Janssens de Bisthoven et al. 2017). Traditional health practitioners also have potential to be sustainable utilisation ambassadors among Indigenous communities that hold them in high regard (Simelane and Kerley 1998). Collaborations with custodians of traditional culture have already demonstrated potential to conserve natural ecosystems in Brazil (Nimmo et al. 2020) which is a biologically and culturally diverse country (similar to South Africa).

South African environmental legislation encourages raising awareness of biodiversity to enable participation in initiatives to conserve this biodiversity (Republic of South Africa 1998). Awareness of local biodiversity is generally raised through interactions with herptiles in cultural practices. The practices categorised under religion, totemism, and poetry can further be beneficial to conservation planning by creating positive perceptions towards herptiles. Incorporation of cultural practices in conservation planning is subject to limitations of cultural practices which are often specific to an area inhabited by a specific cultural group, thus limiting the scope of some protective practices to an area to which they are localised. As conservation planning tends to be centred around species, the deification of a serpentine, river-dwelling creature might not be useable in conservation contexts as the relevant creature is likely mythical based on available descriptions. As totem animal species differ according to people's clans, it is most suited to be a conservation tool for local ordinances of areas that are dominated by relevant clans. For the few animal species that are totems for multiple clans across cultural groups across South Africa (e.g., *C. niloticus*) totemism presents an opportunity to use the charismatic species approach and could also be integrated into the national conservation planning. Similar to the 'Big 5' megafauna being used to rally conservation support (mainly through tourism) for many protected areas in South Africa, totems that are relevant to multiple clans can be conservation mascots among their relevant clans to promote protection of the totem species and their habitat, thus inadvertently leading to associating the protection of a particular area to the protection of a culturally

important species. South African customary law provisions would then afford local traditional authorities/councils the power to deal with any matters that negatively impact the totem species and the habitat required for its survival, provided punishment for transgressions is in conjunction with common law (at either local, provincial, or national level). Such an approach to using totems as charismatic species might require coordination between multiple traditional councils whose community members have one totem in common. In the case of protective cultural practices that are only confined to the jurisdiction of only one traditional council, punishment of transgressions would then be dealt with by the local council in question and in conjunction with local ordinances.

Conservation challenges of herptile-based cultural practices

Integrating protective cultural practices into conservation could unwittingly create the impression that all cultural practices are justifiable in modern conservation contexts and possibly increase the popularity and thus the frequency of cultural practices that negatively impact herptile populations. The use of vertebrate animals in traditional medicine is already a conservation concern (Still 2003), and integrative conservation could unwittingly be seen as unconditional approval of traditional medicine thus exacerbating related conservation concerns. Quantities of animals being used in traditional medicine are expected to increase in many African countries with the proliferation of traditional medicine (Soewu and Adekanola 2011). From this study, we found the number of reptile species (belonging to Crocodylia, Squamata, and Testudines) used in traditional medicine in South Africa to be more than anurans (Table 1), and this is also the case in a study of herptile use in traditional medicine in South African cities (Phaka et al. in press) and globally (Alves et al. 2013). This pressure on reptiles may increase given that the quantities of animals required for traditional medicine could increase as the human population grows (Soewu and Adekanola 2011), and there is no indication that traditional medicine use will decrease (Soewu 2013). Reliance on traditional medicine in Sub-Saharan African countries is not diminishing (Wiersum and Shackleton 2005). Of the countries that are member states of the World Health Organisation, 88% of them acknowledged the usage of traditional medicine by their citizens (WHO 2019).

The seasonal and species-specific focus of some practices might pose a conservation challenge and it will require further research to adequately quantify this risk. Opportunities for people to hunt *Pyxicephalus adspersus* (Giant Bullfrog) are specific to the mating season when they emerge from their subterranean aestivation chambers and hunting them could negatively impact their mating and populations depending on the number of individuals removed from a population. High harvest rates during seasonal hunting can cause local extinctions of the hunted species (Brook et al. 2019). Since totem animal species are specific to their respective clans, totemism will not prevent animals from being excessively utilised by members of different clans. Non-totemic taboos that afford animals protection also tend to be specific to clans, thus limiting their potential effectiveness in conservation. Another limitation stems from the lack of specific indigenous names for all species known to science thus making it difficult to confirm the identity of some species. The lack of specific indigenous names for snakes, in particular, is a problem as people tend to persecute all snakes out of fear since

general names do not enable distinction between harmless and potentially dangerous species of snakes (Simelane and Kerley 1997). There are also negative perceptions about herpetofauna which can threaten their populations (Ceriaco 2012). The association of undesirable qualities (e.g., deception, tardiness, witchcraft, etc.) with some herptile species in traditional cultural lore might also lessen the chance of people empathising with those animals' conservation issues. Some of the undesirable qualities that are associated with herptiles through cultural norms can lead to people fearing them and subsequently being less inclined to protect herptiles (Brom et al. 2020).

The shortfall with taboos and myths as a tool to encourage precaution towards the use of natural resources is that their enforcement depends on people subscribing to the relevant culture. Furthermore, guidelines for punishment when someone disregards those cultural norms meant to protect sacred natural areas may not be well-established due to an assumption that community members are unlikely to test the validity of the long-standing myths and taboos. This study's questionnaire fell short in its exploration of cultural penalties for non-compliance with protective nature-based cultural practices. Further research is thus necessary to understand the scope of customary law punishment and enforcement tools specifically relating to wildlife conservation. More research is also necessary to investigate the applicability of different protective cultural practices to understand whether they are useable at national, provincial, or local level.

Conclusion and Recommendations

The study provides an overview of conservation prospects and challenges that emerge from nature-based cultural practices. This work contributes to herpetofaunal conservation by bridging herpetology (natural sciences) with cultural anthropology (social sciences) and by increasing the understanding of human activities that impact herptile populations both positively and negatively. Further research is required to quantify the impacts (both negative and positive) of herptile-based cultural practices. The variation of protective cultural practices across clans and cultural groups presents an opportunity to customise them into culture-specific conservation measures used in local ordinances. Such a survey of cultural practices' spatial distribution can be combined with the currently lax collaboration between conservationists and custodians of traditional culture. Collaborations of this kind would promote integrative conservation as envisioned by NEMA and NBSAP. Without consultation, there is reliance on *a priori* measures to lessen threats resulting from understudied herptile-based cultural practices, thus leading to conservation measures that continue to overlook local wildlife perspectives.

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ORCID

Fortunate M Phaka http://orcid.org/0000-0003-1833-3156
Jean Hugé http://orcid.org/0000-0002-3695-547X
Maarten PM Vanhove http://orcid.org/0000-0003-3100-7566
Louis H du Preez http://orcid.org/0000-0002-3332-6053

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