Herpetological Conservation and Biology 21(1):226–239.
Received: 13 March 2024; Accepted: 11 March 2026; Published: 30 April 2026.

A Transboundary Terrestrial Herpetological Survey for the Maputo National Park-Tembe Elephant Park Complex, Mozambique and South Africa

Philip R. Jordaan[1,2,5], Catariné C. Hanekom[3], and Miguel Gonçalves[4]

[1]*Maputo National Park and Tembe Elephant Park, Mozambique and South Africa, 2018-2020*
[2]*African Ecological Conservation Projects (Pty) Ltd., Baltimore st 7, Centurion, South Africa*
[3]*Ezemvelo KwaZulu-Natal Wildlife, Tembe Elephant Park, South Africa*
[4]*Administração Nacional das Áreas de Conservação, Maputo National Park, Mozambique*
[5]*Corresponding author, e-mail: PRJordaan@aecproject.org*

***Abstract.*—As part of the transboundary cooperation between components of the Lubombo Transfrontier Conservation Area, we conducted three herpetological surveys across the Maputo National Park (Maputo province, Mozambique) and Tembe Elephant Park (KwaZulu-Natal province, South Africa) complex over the 2019/2020 austral summer. The total survey consisted of 44 pitfall and funnel trap arrays across the dominant terrestrial vegetation types for each of the protected areas creating a baseline to inform future research and monitoring. The Tembe Elephant Park survey (18 pitfall and funnel trap arrays) recorded a total of 10 amphibian and 30 reptile species, whilst the Maputo National Park surveys (26 pitfall and funnel trap arrays) recorded 13 amphibian and 41 reptile species. The sum of these surveys across the complex recorded 13 amphibian and 44 reptile species. These surveys produced several reptile range extensions for the complex, including the first record of a globally Near Threatened species for Mozambique. Our study underrepresented amphibian species richness, however, due to the exclusion of aquatic habitats from the sampling design. Based on the data, we recommend future additional assessments and monitoring programs for the conservation of herpetofauna in both protected areas and the general region.**

Key Words.—Futi corridor; Maputaland; Maputo Special Reserve; Maputo Elephant Reserve; Mozambican Coastal Plain; Sand Forest

Introduction

The Lubombo Transfrontier Conservation Area (LTFCA) is composed of several protected areas across eSwatini (formerly Swaziland), southern Mozambique, and eastern South Africa (Tembe Elephant Park [TEP] 2009, Direção Nacional de Áreas de Conservação [DNAC] 2010); however, due to the scattered locations of these sites, most of its constituent protected areas are unable to be connected across international borders. Following the proclamation of the Futi Corridor (FC) section of the Maputo National Park (MNP) in Maputo province, Mozambique, this protected area and Tembe Elephant Park in KwaZulu-Natal province, South Africa are currently one of the only sections of the LTFCA able to create a continuous conserved terrestrial landscape across international borders (Fig. 1; TEP 2009, DNAC 2010). Consequently, the two protected areas have assisted one another in various conservation operations such as the facilitation of aerial wildlife surveys, cooperative law enforcement, and the re-establishment of wildlife populations. As part of this continued transnational cooperation, both protected areas jointly conducted baseline herpetological surveys across the MNP-TEP complex in fulfillment of mutual conservation objectives (TEP 2009; DNAC 2010).

The herpetofauna of TEP has been the subject of multiple studies (Pretorius 2019; Reeder 2019; Jordaan et al. 2020), including a short pitfall and funnel trap (PFT) survey (Jordaan et al. 2023), and regionally the reptile and amphibian diversity of northern KwaZulu-Natal was initially assessed by Bruton and Haacke (1980) and Poynton (1980), respectively. In contrast, research into the herpetofauna of southern Maputo province and MNP has received little attention. Information on the reptile and amphibian diversity for MNP primarily consists of species lists for the protected area and its surroundings compiled by Tello (1973), and a localized study investigating the effect of exotic plantations on herpetofaunal diversity around the MNP headquarters (Jordaan et al. 2024).

We conducted PFT surveys across the dominant terrestrial vegetation designations of the MNP-TEP complex with the aim of contributing to

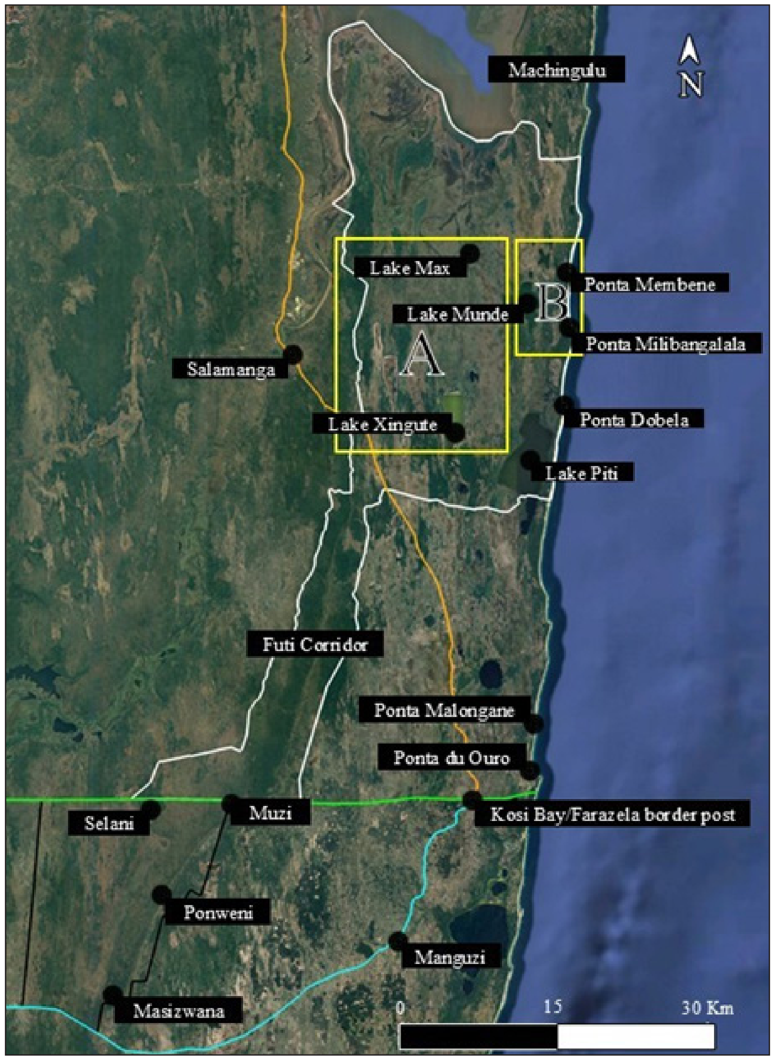

Figure 1. The Maputo National Park-Tembe Elephant Park complex (outlined in white and black respectively), stretching across the Mozambique/South African international border (green line), in relation to the P522 (blue) and the N200 (orange) roadway, Salamanga village, the towns of Ephondweni, Ponta du Ouro, Ponta Malongane, and Manguzi, as well as the Kosi Bay-Farazela Border post. Various other natural features and landmarks referred to in the article are also included. Yellow blocks A and B indicate the extent of the two MNP surveys in Supplementary Information Figure S2.

the herpetological inventories for both protected areas and establish quantified baselines for future monitoring programs and research projects. We documented the capture frequencies of herpetofauna for each PFT array and vegetation designation. We subsequently assessed the environmental associations of reptiles and amphibians with high capture rates to identify potential indicator species. We provide additional supporting information with regards to morphometric measurements and new geographical records derived from the survey results and suggest future regional herpetological conservation projects and research. We also comment on logistical and practical challenges experienced during fieldwork.

Materials and Methods

Study site.—While the LTFCA incorporates several protected areas that have agreed to work together to further transnational conservation goals, each area maintains state-sanctioned autonomous management. As such, the Mozambican conservation state entity Administração Nacional das Áreas de Conservação (ANAC) manages MNP (DNAC 2010) and Ezemvelo KwaZulu-Natal Wildlife (EKZNW), the KwaZulu-Natal provincial conservation authority, manages TEP (TEP 2009). The international border separating MNP and TEP does not follow any physical or geographical features such as a river course or a mountain range but is rather a product of mitigation

Figure 2. The international border fence line between Tembe Elephant Park, South Africa (left), and Maputo National Park, Mozambique (right). (Photographed by Philip R. Jordaan).

efforts over disputed colonial territorial boundaries between the British and Portuguese during the 19th Century, known as the MacMahon award 1874/1875 (Bruton et al. 1980).

As with many international boundaries with a colonial origin, this section of the border is almost perfectly straight, cutting across contours and natural features such as the Selani/Nsalane Forest. Consequently, the immediate physical environment and biological communities on either side of the border are essentially the same. As such, any assessments proposing this section of the border as a boundary to the distribution of species should be viewed with caution, as the lack of evidence for such species in southern Mozambique is likely an artifact of limited sampling in the area rather than their actual absence (e.g., Large Scale Grass Lizard, *Chamaesaura macrolepis*; see Jordaan 2020). The fence separating the two protected areas is, however, still currently in place (Fig. 2). This barrier limits, but does not eliminate, the movement of all large wildlife species between the two protected areas (Henley et al. 2023), and various smaller animals, including reptiles and amphibians, have been observed moving across the border (pers obs.).

Originally, the terrestrial portion of MNP, formally known as Maputo Special Reserve (1969–2022) and Maputo Elephant Reserve (1932–1969), stretched from the Maputo River mouth and Maputo Bay south along the Indian Ocean coast to the southern extent of Lake Piti and inland towards the Futi River. With the assimilation of the FC into MNP, the protected area was extended along the Futi River to the international border with South Africa. The inclusion of the FC (24,000 ha) into MNP increased the terrestrial section of the protected area to 104,000 ha (https://parquemaputo.gov.mz/en/the-park/about/). In 2021, the Maputo Special Reserve and Ponto du Ouro Partial Marine Reserve were combined into a single protected area to form MNP (https://parquemaputo.gov.mz/en/the-park/about/). The recently tarred N200 roadway (completed in 2018) runs through the northern section of the FC. TEP stretches south of the international border until the P522 tarred roadway. The total area of TEP encompasses 30,015 ha (Matthews et al. 2001; Fig. 1). The combined geographical extent of the continuous terrestrial area of the MNP-TEP complex is roughly 134,000 ha.

The complex is situated along the Mozambican/Maputaland Coastal Plain, with the edaphic environment largely dominated by fine sand deposits of aeolian and marine origins forming vegetated dunes and plains (Matthews 2001; DNAC 2010), devoid of any naturally occurring rocky terrestrial features. TEP only has one natural permanent water source, the Muzi Swamp, with some additional relatively small ephemeral pan systems scattered throughout the protected area (Matthews et al. 2001). The Muzi Swamp from TEP runs north crossing the international border into MNP and is known as the Futi River in Mozambique. Besides the Futi River, MNP has a wide variety of other water sources ranging between a series of lakes (the largest being Lake Piti, spanning approximately 2,500 ha), relatively extensive wetlands, and the Maputo River and Ponta Dobela estuaries, as well as permanent and temporary pans (DNAC 2010). The complex falls within the Maputaland Centre of Endemism (Smith et al. 2008), which harbors a high phytodiversity and a wide variety of habitat types, ranging from Sand Forest and Coastal Dune Forest to several different savanna, woodland and grassland vegetation types (Tello 1973; Matthews et al. 2001; DNAC 2010).

Regular fires commonly occur throughout the savanna and grassland components of the MNP-TEP complex, especially during the dry winter months. While fire management protocols exist for both protected areas, unplanned fires do occur, often originating from burning activities conducted by local communities. Small villages and communities are resident in MNP, but not in TEP.

Except for some small antelope species, Hippopotamus (*Hippopotamus amphibius*), Savanna Elephant (*Loxodonta africana*), and Nile Crocodile (*Crocodylus niloticus*), most other wildlife were extirpated from MNP during the Mozambique civil war (1977–1992). A recent reintroduction operation has successfully re-established several wildlife species to the area, including Cape Buffalo (*Syncerus caffer*), Southern African Giraffe (*Giraffa giraffa*), Nyala Antelope (*Tragelaphus angasii*), Impala (*Aepyceros melampus*), Burchell's Zebra (*Equus quagga burchellii*), and Blue Wildebeest (*Connochaetes taurinus*; Catheriné Hanekom, unpubl. report). In contrast, TEP has harbored significant wildlife populations since the 1980s, with Savanna Elephant and Nyala Antelope being managed to keep wildlife population numbers and associated habitat modifications (especially vegetation impact) within acceptable limits (TEP 2009).

Pitfall and funnel trap surveys.—We placed PFT arrays according to the vegetation designations produced in DNAC (2010) for MNP and Matthews et al. (2001) for TEP. The MNP surveys covered five natural vegetation designations (Coastal Dune Forest, Coastal Grassland, Sand Forest, Sand Thicket, and Woody Grassland), as well as rehabilitated and derelict *Eucalyptus* plantations. We selected the four largest terrestrial vegetation types (Closed Woodland, Open Woodland, Sand Forest, and Sparse Woodland) for the TEP survey. We excluded all aquatic habitats, such as wetlands, swamps and pan systems, from these surveys; however, some PFT arrays were situated in the general vicinity of water sources. Brief descriptions and the coordinates of each PFT array conducted during these surveys are provided in Supplementary Information Table S1. We based the general PFT array structure for our surveys on the design promoted in the South African National Biodiversity Institute (2020) publication. The array design incorporated terminal funnel traps, pitfall traps, and double-sided funnel traps (Fig. 3) arranged along three drift fences radiating out from a central point at roughly 120° relative to each other (Fig. 4).

The construction of drift fences entailed linking eight plastic corru-board/Coroplast sheets (Coroplast, Vanceburg, Kentucky, USA) of 1.25 × 0.4 m to form 10 m long sections. Originally, we connected the Coroplast sheets with strips of canvas material and contact adhesive as suggested in the South African National Biodiversity Institute (2020) publication, but after damage inflicted by elephants at two survey sites in TEP, we systematically replaced the canvas with velcro, stapled in position along the edges of individual Coroplast sheets. This change in materials allowed for the rapid repair of drift fences in the wake of elephant damage and prevented excessive damage to the Coroplast sheets (Jordaan 2022). To secure drift fences in position and prevent animals from moving under these barriers, we inserted the bottom edge of drift fences into 0.1 m deep grooves we dug into the soil. For additional stability, we anchored drift fences in position with several metal pegs (0.45–0.6 m long and diameter of 2–3 mm) along the internal Coroplast flutes. When minor damage occurred, we repaired the drift fences with duct tape.

We constructed terminal funnel traps (Fig. 3) by inserting an open-ended hazard cone through a hole (150 mm diameter) cut into the center of a Coroplast sheet (1.25 × 0.4 m). We folded the sheet into an angular U-shape, creating an extended funnel. Cones were secured to the sheet with screws and bolts. We fitted a cylinder of 2 × 2 mm enameled iron mesh netting, 0.9 m in length and capped with a 0.3 m section of PVC pipe (100 mm diameter) or a circular plastic container/bottle with duct tape, to the outside of the hazard cone, creating a large single-sided funnel trap. We installed these traps at the end of each of the three drift fences of the PFT array. By inserting metal pegs through the internal flutes of the terminal funnel trap sheet, the opening of the hazard cone was secured against the end of each drift fence. We added sand to the bottom lip of the hazard cone to create a sloping ramp to assist animals with entering these traps. As with the drift fences, we inserted the bottom 0.1 m of the Coroplast sheet into the soil along dug out grooves. To shield captured animals from exposure, we placed stacks of grass and other vegetation on the ends of the terminal funnel traps.

Pitfall traps consisted of 20-L plastic buckets dug into the soil deep enough to position the bucket

Figure 3. The different survey traps employed during the pitfall and funnel trap survey. (A) Terminal funnel trap containing a De Coster's Garter Snake (*Elapsoidea sundevallii decosteri*). (B) A pitfall trap with an accompanying drift fence. (C) A large double-sided funnel trap containing a Brown Forest Cobra (*Naja subfulva*; total length: 1,614 mm). (D) A small double-sided funnel trap containing two Short-snouted Grass Snakes (*Psammophis brevirostris*). (Photographed by Philip R. Jordaan).

openings 0.1 m below the surrounding soil surface (Fig. 3). This allowed drift fences to bisect the openings of pitfall traps. Each PFT array contained four pitfall traps, one in the center of the array with single traps at the 5 m mark of each of the three drift fences. We placed halved bucket lids suspended on wooden pegs to provide cover to pitfall traps to shield captured animals from exposure. We added wet sponges and a layer of sand, up to 30 mm deep, to retain moisture in pitfall traps and prevent the desiccation of captured animals. The sand also provided shelter for burrowing species. Small holes in the bottom of buckets allowed water to drain from traps. When excessive rainfall flooded pitfall traps, we physically removed waterlogged sand and excess water during daily checks with small plastic containers.

Double-sided funnel traps consisted of 2 × 2 mm enameled iron mesh netting stapled in place to envelop two inward facing plastic funnels. We constructed two sizes of double-sided funnel traps, with large funnels taken from 5-L water bottles, and small funnels taken from 2-L soft drink bottles (Fig. 3). Both sizes of double-sided funnel traps were approximately 0.55 m in length. A strip of velcro that we fitted to the top of double-sided funnel traps allowed fieldworkers access to captured specimens. We placed one large and one small double-sided funnel trap on opposite sides of each drift fence, resulting in a total of three large and three small double-sided funnel traps per PFT array. By adding sand to the bottom edges of the plastic funnels, we filled any gaps between the traps and the Coroplast sheet and secured double-sided funnel traps along drift fencing, decreased the funnel angle, and provided increased traction for animals entering these traps (Jordaan et al. 2023). We used herbaceous material, woody foliage, or large pieces of bark to cover double-sided funnel traps, shielding captured animals from exposure.

The TEP survey commenced on 2 December 2019 and consisted of 18 PFT arrays (Supplementary Information Fig. S1). While we initially planned to survey each of the four selected vegetation types using five PFT arrays, significant elephant damage during the installation phase of some arrays resulted in insufficient survey materials (Jordaan 2022).

Figure 4. (A) An aerial view of the pitfall and funnel trap array structure (Maputo National Park, Coastal Grassland). (B) A ground level view of an installed array in degraded sand forest (Tembe Elephant Park, Sand Forest) with high level of herbivore damage resulting in a general lack of an understory. (Photographed by Philip R. Jordaan).

Subsequently we only surveyed Open Woodland and Sparse Woodland at four locations. To limit additional elephant damage to our equipment, we surrounded PFT arrays in areas with high elephant traffic with string coated in chili powder suspended from vegetation above the ground as a deterrent (Jordaan 2022). Each array was active for 21 nights, although several PFT arrays needed to be deactivated to repair elephant damage to survey structures and due to excessively high temperatures to prevent trap mortalities. When individual PFT arrays reached an active period of 21 days, we removed trap sites from the field. We removed the last sites 30 December 2019. The extent of the survey ranged from the south-western to the north-eastern corner of TEP along an 87 km route of the internal road network, which we drove daily to check sites.

We conducted two PFT surveys on MNP due to the size and scope of the planned assessment. The survey assessing the western and central section of MNP stretched from the N200 tarred roadway to Lake Max. We conducted the survey during January and early February 2020 and included three indigenous vegetation types; Sand Forest, Sand Thicket, and Woody Grassland as well as old *Eucalyptus* plantations (Supplementary Information Fig. S2). We installed four PFT arrays within each habitat category. We activated the survey on 12 January 2020. Due to mechanical failure of the survey vehicle, we deactivated PFT arrays for 5 d in the middle of the survey until the vehicle was repaired. We removed PFT arrays after 17 survey days. We removed the last PFT arrays 5 February 2020. Array locations were situated along a 75 km route.

We surveyed the eastern section of MNP March 2020 using 10 PFT arrays over three vegetation types, with Coastal Dune Forest and Coastal Grassland each surveyed at four locations, and Sand Forest surveyed at two locations (Supplementary Information Fig. S2). The survey stretched from north of Ponta Membene, inland to Lake Munde and as far south as Ponta Milibangalala along a 35 km route. Arrays were active from 10–27 March 2020 with the survey running for 17 consecutive days.

All arrays were inspected daily to record and remove captured herpetofauna and by-catch. For each captured amphibian and reptile, we recorded the date of capture as well as the species, trap site, and specific trap type (pitfall trap, double-sided-funnel trap, terminal funnel trap). We used Du Preez and Carruthers (2017) to identify amphibians, and Branch (1998) for reptiles with the nomenclature updated in accordance with Uetz et al. (2023). *Scelotes* species were identified using Broadley (1994). We temporarily collected herpetofauna for morphometric measurements, i.e., snout-vent length (SVL), tail length (in mm), and mass (g) before we released captures away from PFT array locations to prevent recaptures. We removed venomous snakes from traps and an experienced and accredited individual (PRJ) handled them with appropriate safety equipment to prevent envenomation of the handler.

We immediately released all small mammal, avian (we captured a Crested Guineafowl, *Guttera edouardi*, chick in a pitfall trap), and invertebrate bycatch at the site of capture. When daily temperatures were forecast to reach 40° C or higher, we deactivated PFT arrays in more open habitats such as grassland, Open Woodland, and Sparse Woodland to prevent trap mortalities. When trap mortalities did occur, we fixed specimens in 10% buffered formalin and transferred the material to 70%

ethanol. We curated voucher specimens originating from TEP in the herpetological collection of the Port Elizabeth Museum (PEM) in Gqeberha. Collected material originating from MNP were housed at the MNP management headquarters. We uploaded representative photographic records to the virtual museum of the Biodiversity Development Institute (BDI) in the FrogMAP (FM; http://www.vmus.adu.org.za/vm=frogMAP) and ReptileMAP (RM; http://www.vmus.adu.org.za/vm=ReptileMAP) projects.

Data treatment and analyses.—To enable quantitative comparisons of capture results between habitat categories and individual PFT arrays, we calculated the catch per unit effort (CPUE; Fischer and Rochester 2012) by dividing the number of captures for reptiles, amphibians, and/or species by the number of trap nights (number of traps × number of arrays × active days). We calculated trap nights for PFT arrays in the MNP surveys at 221 (13 traps × 1 array × 17 d active) and for TEP at 273 (13 traps × 1 array × 21 d active). We calculated habitat associated CPUE by calculating the sum of all captures for PFT arrays for a specific vegetation designation and dividing it by the total effort across all arrays. Additionally, we compiled species accumulation curves for the TEP and MNP surveys illustrating the rate at which new species were documented for each vegetation delineation and protected area over the survey period.

Results

We deployed 44 PFT arrays across the extent of the MNP-TEP complex: 18 in TEP and 26 in MNP. We recorded 57 species of herpetofauna, 13 amphibian, and 44 reptile species during the three surveys for the MNP-TEP complex. The CPUE across the MNP-TEP surveys for all herpetofauna was 0.081. Total herpetofaunal captures for TEP amounted to 457 individuals over 40 species with a CPUE of 0.093. Captures across MNP for all herpetofauna numbered 601 individuals over 54 species with a CPUE of 0.105.

The TEP PFT survey recorded 10 amphibian species over 231 captures with a CPUE of 0.047 (Supplementary Information Table S6). The MNP PFT surveys recorded 13 amphibian species over 223 specimens and a CPUE of 0.039 (Supplementary Information Table S7). The highest amphibian species richness was recorded in Closed Woodland (10 species) and Sand Forest (13 species) with the lowest number of species captured in former *Eucalyptus* plantations (one species).

The TEP PFT survey recorded 30 reptile species over 226 captures with a total CPUE of 0.036 Supplementary Information Table S12). The MNP PFT surveys recorded 41 reptile species over 378 individuals with a CPUE of 0.066 (Supplementary Information Table S13). Reptile species richness was highest in savanna (Sand Thicket = 21 species, Open Woodland = 17 species) and Closed Woodland (17 species). The lowest reptile species richness was recorded in Coastal Dune Forest (14 species) and Sand Forest (TEP = 12 species). The capture results for each of the 44 PFT arrays, including the number of individuals captured per array, as well as the CPUE for each array and habitat category for amphibians are provided in Supplementary Tables S2–S5 and for reptiles in Supplementary Tables S8–S11. Both the habitat and the overall amphibian species accumulation plateaued early during surveys whereas reptile species accumulation generally continued to increase for the majority of PFT habitat categories till the end of survey periods (Supplemental Information Figs. S4 and S5).

Discussion

Our surveys are the first terrestrial habitat scale quantitative herpetofaunal assessments conducted for either MNP or TEP and the first collaborative cross-border herpetological assessment within the LTFCA and Maputaland. In addition to new geographic distribution extensions for some reptile species, our surveys provide quantitative data on habitat associated with herpetofaunal communities that could be implemented as baseline assessments for future monitoring programs across the MNP-TEP complex. Currently, the only herpetological monitoring taking place within the MNP-TEP complex focus on marine turtle nesting along the MNP coastline (Fernandes et al. 2021), and aerial counts of Nile Crocodiles as part of the semi-annual wildlife censuses (Cateriné Hanekom, unpubl. report). A more comprehensive crocodile monitoring strategy has, however, been developed for MNP (Jordaan 2021b).

During our surveys, amphibian species accumulation reached an asymptote before the end of surveys across all vegetation designations, which would suggest that most of the common frog species available for capture during the sampling periods were recorded during our surveys. Prior surveys conducted during different seasons at some of the same areas

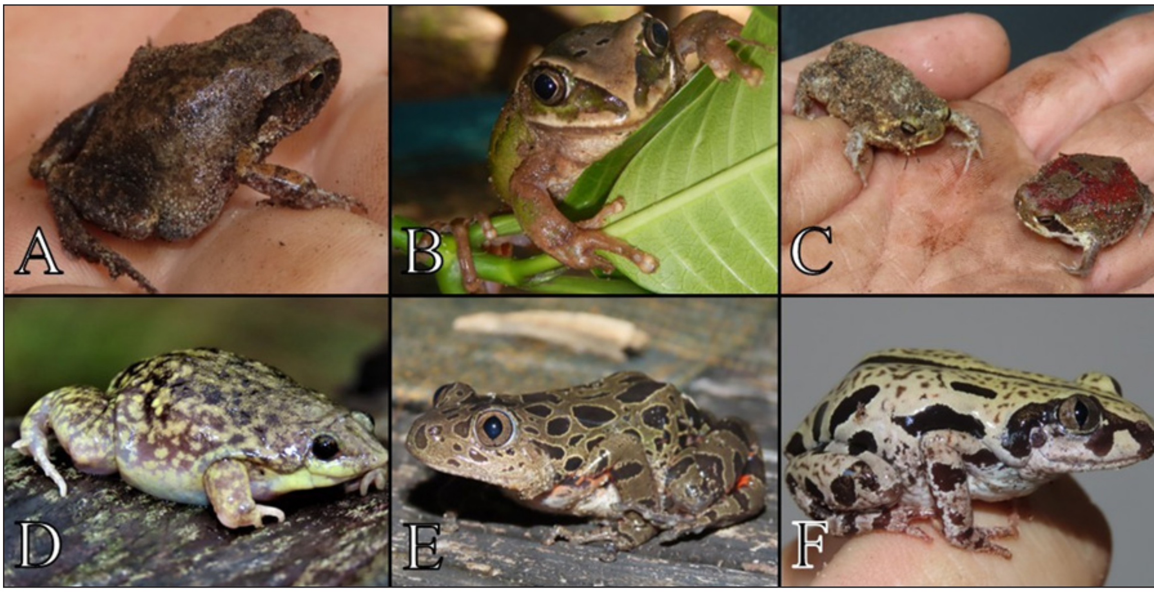

Figure 5. (A) Shovel-footed Squeaker, *Arthroleptis stenodactylus*, (B) Brown-Back Tree Frog, *Leptopelis mossambicus*, (C) Mozambique Rain Frog, *Breviceps cf. mossambicus*, (D) Mottled Shovel-nosed Frog, *Hemisus marmoratus*, (E) Red-legged Kassina, *Hylambates maculatus*, and (F) Bubbling Kassina, *Kassina senegalensis*. (Photographed by Philip R. Jordaan).

across MNP (Jordaan et al. 2024) and TEP (Jordaan et al. 2023), however, captured additional terrestrial amphibian species than our 2019/2020 survey. For instance, a PFT survey conducted in MNP over April and May 2018 encountered three amphibian species in rehabilitated *Eucalyptus* plantations and four in derelict plantations (Jordaan et al. 2024), but we only recorded one amphibian species, the Mozambique Rain Frog (*Breviceps* cf. *mossambicus*). The identity of our capture is based on the phylogenetics of the *B. mossambicus* complex and Heinicke et al. (2021) suggests that it is new cryptic species in the region.

Surface water independent anuran species made up most of the total amphibian sample across the MNP-TEP surveys. The two most captured amphibians were the Shovel-footed Squeaker (*Arthroleptis stenodactylus*; n = 86; Fig. 5) and the Mozambique Rain Frog (*Breviceps* cf *mossambicus*; n = 245; Fig. 5). *Breviceps* cf. *mossambicus* captures were more prevalent in native grassland and savanna habitats compared to forest, while the Shovel-footed Squeaker was only recorded in Closed Woodland and forest habitats.

In contrast to the amphibian results, reptile species accumulation during our surveys rarely reached a plateau, indicating that increased survey efforts will likely produce additional species both within habitat designations as well as for the MNP-TEP complex. This has been corroborated by previous surveys that documented several reptile species not recorded during the 2019/2020 survey (Jordaan et al. 2020, 2023, 2024). The most captured reptile species across the MNP-TEP complex were Fornasini's Blind Snake (*Afrotyphlops fornasinii*; n = 62), Wahlberg's Snake-eyed Skink (*Panaspis wahlbergii*; n = 64), and Yellow-throated Plated Lizard (*Gerrhosaurus flavigularis*; n = 95; Fig. 6). No Yellow-throated Plated Lizard or Wahlberg's Snake-eyed Skink captures occurred in Closed Woodland or forest habitats. Yellow-throated Plated Lizard CPUE was generally higher in grassland, while Wahlberg's Snake-eyed Skink was more prevalent in savanna habitats. Fornasini's Blind Snake was captured at higher rates in Closed Woodland and forest habitats than grassland and savanna areas and was only represented by a single capture in rehabilitated *Eucalyptus* plantations (see Jordaan and Wilken 2022).

Some herpetofauna may be sensitive to variations in land use and environmental changes, which could prove viable as environmental indicators (Masterson et al. 2008; Russel and Downs 2012). For species to act as indicators, they must be represented at high abundances during surveys, easily identified or distinguished from other species, associated with specific ecosystem features, react to modifications made to the environment, and such responses must be able to be distinguished from natural variations (Russell and Downs 2012). By comparing variations in habitat structure and PFT capture rates, quantified reactions may inform which, if any, high

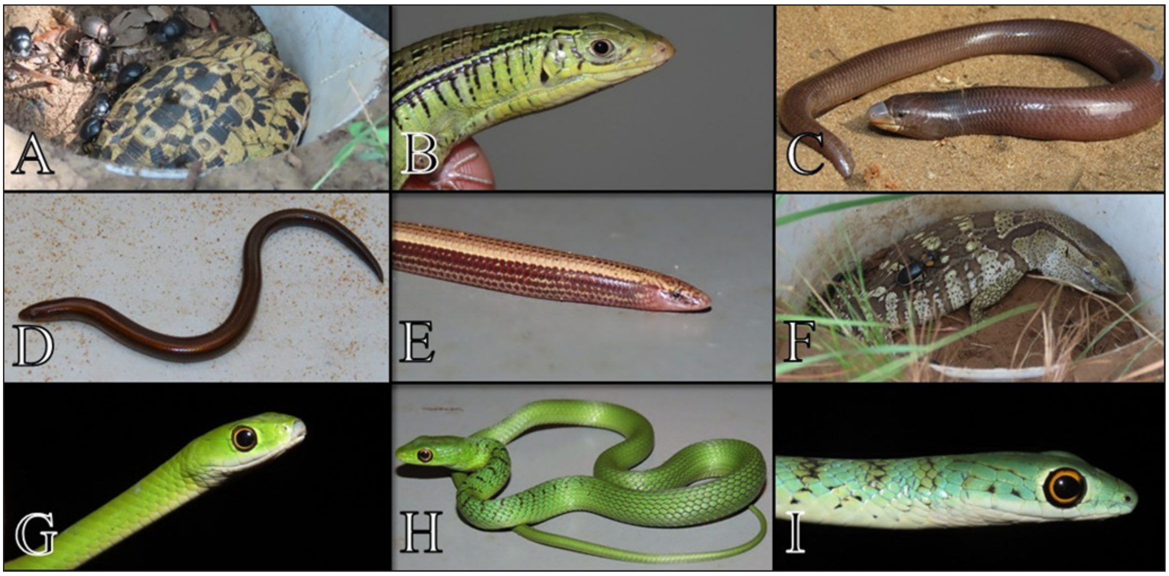

Figure 6. (A) Eastern Hinge-back Tortoise, *Kinixys zombensis*, (B) Yellow-throated Plated Lizard, *Gerrhosaurus flavigularis*, (C) Giant Legless Skink, *Acontias plumbeus*, (D) FitzSimons' Dwarf Burrowing Skink, *Scelotes fitzsimonsii*, (E) Coastal Dwarf Burrowing Skink, *Scelotes vestigifer*, (F) Rock Monitor, *Varanus albigularis albigularis*, (G) South-eastern Green Snake, *Philothamnus hoplogaster*, (H) Natal Green Snake, *Philothamnus natalensis*, and (I) Spotted Bush Snake, *Philothamnus semivariegatus*. (Photographed by Philip R. Jordaan).

abundance species can act as indicators of faunal responses to environmental change, such as altered fire and herbivore management regimes or woody encroachment.

Due to the strong associations between Fornasini's Blind Snake capture rates and woody vegetation cover, this species could be a viable candidate to gauge faunal responses regarding modifications to vegetation structure such as the impact of elephant stocking rates or deforestation (Jordaan and Wilken 2022). Mozambique Rain Frog has been suggested as a possible indicator species of environmental disturbance or change by Jordaan et al. (2023; 2024). The CPUE of Mozambique Rain Frog during our surveys were generally higher at sites that burned during the preceding winter (2019) than sites that were not. This is similar to what was reported by Jordaan et al. (2023) during a previous winter PFT survey on TEP. Also, when comparing the Mozambique Rain Frog CPUE between rehabilitated and derelict *Eucalyptus* plantations, we observed the same general trend of higher captures in derelict plantations versus rehabilitated plantations, as reported by Jordaan et al. (2024). Our results were lower, however, for CPUE in rehabilitated and derelict plantations (0.009 and 0.023) than the previous survey (0.017 and 0.053), likely due to lower rainfall during the 2020 survey period.

Our surveys produced several new reptile geographical distribution records for the MNP-TEP complex. This included one of the first records of Line Shovel-snout Snake (*Prosymna lineata*) for TEP (Van Huyssteen and Jordaan 2021) and the northernmost records for Fitzsimons' Dwarf Burrowing Skink (*Scelotes fitzsimonsi;* Fig. 6) and Coastal Dwarf Burrowing Skink (*Scelotes vestigifer*; Fig. 6) in MNP (Jordaan 2021a). Two records of Pygmy Wolf Snake, *Lycophidion pygmaeum* (Fig. 7) in MNP constituted both the northernmost records of the species as well as the first evidence of its presence in Mozambique (Jordaan et al. 2020). This is also the only herpetofaunal species of conservation concern captured during our surveys, currently listed globally as Near Threatened on the International Union for the Conservation of Nature Red List (Alexander et al. 2022). We documented new maximum size records (Supplemental Information Table S14) for Fornasini's Blind Snake and the Eastern Purple Glossed Snake (*Amblyodipsas microphthalma microphthalma*; Fig. 7). A large De Coster's Garter Snake (*Elapsoidea sundevallii decosteri*) specimen (Fig. 7) we captured during the TEP survey marginally exceeded the maximum size of 800 mm described for the subspecies in Marais (2022); however, Fitzsimons (1962) refers to a specimen measuring 1,064 mm in total length.

Except for the derelict *Eucalyptus* plantation PFT arrays, the FC was not assessed by our surveys. We suggest that herpetological assessments be conducted along the FC before the international border between MNP and TEP is eventually removed. Specifically,

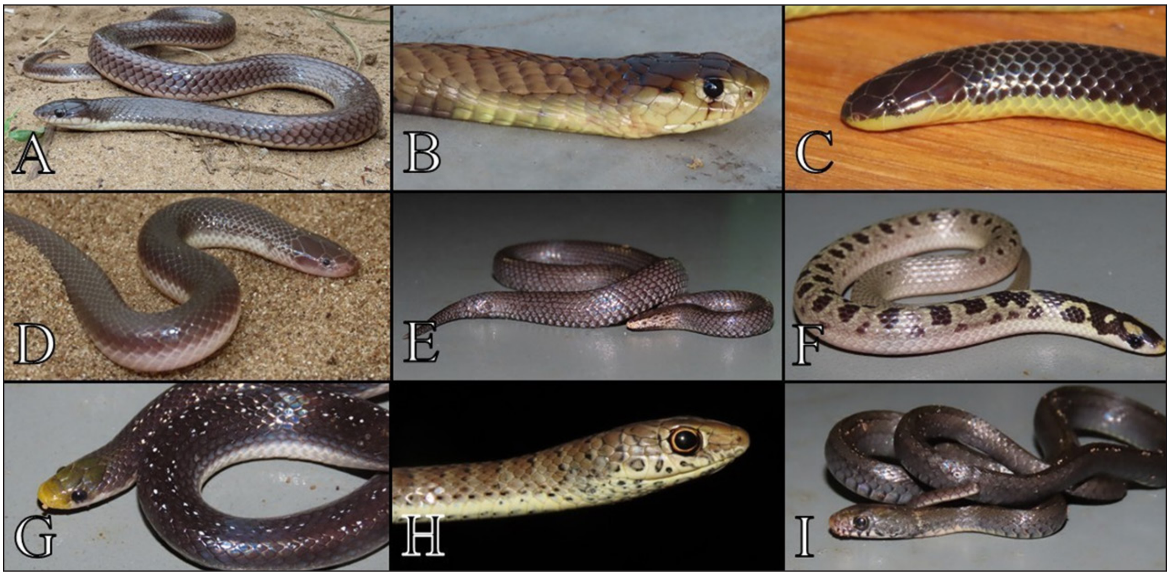

Figure 7. **(A)** De Coster's Garter Snake, *Elapsoidea sundevallii decosterii*, (B) Snouted Cobra, *Naja annulifera*, (C) Eastern Purple Glossed Snake, *Amblyodipsas microphthalma microphthalma*, (D) Bibron's Stiletto Snake, *Atractaspis bibronii*, (E) Pygmy Wolf Snake, *Lycophidion pygmaeum*, (F) Mozambique Shovel-snout, *Prosymna janii*, (G) East African Shovel-snout, *Prosymna stuhlmannii*, (H) Olive Grass Snake, *Psammophis mossambicus*, and (I) Forest Marsh Snake, *Natriciteres sylvatica*. (Photographed by Philip R. Jordaan).

studies assessing the impact of increased elephant and other wild herbivore movement on herpetofauna between the northern (MNP) and southern (TEP) sections of the Selani/Nsalane Forest and its associated grasslands and woodland as well as the Futi River wetlands are advised as the funneling effect of the FC on wildlife movements between TEP and MNP is likely to affect habitat structure. Both positive and negative effects on herpetofaunal diversity have been documented for such habitat modifications (Jansen and Healey 2003, Howland et al. 2014, Nasseri et al. 2010). Added traffic from large mammals may also affect herpetofauna through increased trampling (McCauley et al. 2006).

Other protected areas surrounding the MNP-TEP complex that still require quantitative herpetofaunal assessments or even basic inventories include Sileza Nature Reserve, Tshinini Game Reserve, and Manguzi Forest Reserve in northern KwaZulu-Natal as well as the Lucuati Forest Reserve west of MNP. A herpetological assessment for the Maputo River flood plain is also lacking. Multiple reports dealing with the herpetofauna of Ndumo Game Reserve to the west of TEP have been published (e.g., Pooley et al. 1973; Measey et al. 2009; Pretorius 2019); however, its herpetofaunal diversity has not recently been reviewed in its entirety, nor has a structured assessment been conducted for its terrestrial herpetofauna.

While the results of these surveys have contributed to and confirmed much of the herpetofaunal richness for the MNP-TEP complex, these results should not be seen as a comprehensive herpetofaunal inventory. Many larger species that occur at lower densities, such as Southern African Python (*Python natalensis*), are unlikely to be captured in PFT arrays despite being observed regularly across both protected areas. Similarly, tortoises that also occur at relatively low densities throughout the complex were not well represented during our surveys, with only one Eastern Hinge-back Tortoise (*Kinixys zombensis*; carapace length = 150 mm; mass = 0.81 kg) captured in a pitfall trap (Fig. 6) in Coastal Dune Forest.

Specialized techniques will be required to target specific herpetological assemblages that were not adequately represented or surveyed for with PFT arrays. For instance, wetland-associated amphibians are commonly surveyed nocturnally on foot. Within areas with potentially dangerous wildlife such as our study sites, multiple armed rangers may be required to ensure the safety of field staff, which may be logistically challenging (Jordaan 2022). A safer alternative in such environments would be acoustic surveys that record and identify anuran diversity from male advertisement calls. Such an assessment has already been undertaken along the Muzi swamp on TEP (Pretorius 2019), but wetland amphibian diversity assessments are currently lacking for MNP. This method may also facilitate the regular monitoring of anuran communities throughout the MNP-TEP complex. Road cruises documenting herpetofaunal vehicular mortality along the tarred roadways may both monitor the impact of roads on smaller faunas and contribute additional species to reptile and amphibian inventories (Willson 2016). Many arboreal and obligate fossorial herpetofauna that infrequently move over surface terrain were underrepresented by our PFT surveys and require specialized survey techniques to be quantitatively assessed (Pooley et al. 1973; Measey et al. 2009, Henderson et al. 2016). For example, fossorial quadrat sampling conducted close to the PFT arrays TEP SW C and D produced records of several obligate fossorial reptile species such as the Maputaland Legless Skink (*Acontias parietalis),* Slender Spade-snouted Worm Lizard (*Monopeltis sphenorhynchus)*, Zululand Dwarf Burrowing Skink (*Scelotes arenicolus)*, and Sand-dwelling Dwarf Worm Lizard (*Zygaspis arenicola;* Jordaan et al. 2025), none of which were captured at those PFT sites.

The potential to implement periodic repetitions of the MNP-TEP PFT surveys described here, in conjunction with assessments of other environmental facets may function as a monitoring tool to assess terrestrial herpetofaunal diversity and ecological responses in relation to management actions, stochastic events, and shifts in climate. Future PFT assessments should however be expanded to include the area surrounding Lake Piti and Ponta Dobela as well as the FC for MNP and the northwest of TEP. Surveys may also need to be conducted during spring, summer, and autumn periods to ensure that species that are more mobile during different seasons are represented in surveys (Russell and Downs 2012). Due to logistical constraints, we conducted our surveys at three different time periods during the 2019/2020 austral summer. Future assessments may be improved if all PFT surveys are conducted over the same exact periods. This will, however, require considerably more survey equipment as well as multiple survey teams and vehicles. The increased scope and frequency of surveys will require significantly more funding.

Our surveys provided a general baseline of herpetofaunal richness and diversity to inform future PFT monitoring programs and contributed to the herpetofaunal inventories for both protected areas. A comprehensive herpetofaunal species inventory should be conducted for both protected areas, drawing on multiple types of surveys, confirmed observations, accessioned museum specimens, a review of published accounts, and digital records. The importance of the MNP-TEP complex for regional herpetological conservation is likely to increase with rapid land use changes in both northern KwaZulu-Natal as well as southern Maputo province (e.g., Alexander et al. 2022).

Acknowledgments.—Our surveys were conducted during the tenure of PRJ as the Lubombo Transfrontier Conservation Area Scientific Technician between Maputo National Park (MNP) and Tembe Elephant Park (TEP), a position funded by the Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ) through Peace Parks Foundation in partnership with Administração Nacional das Áreas de Conservação and Ezemvelo KwaZulu-Natal Wildlife. The authors would like to thank Joe S.R. Cutler, Megan Hudson, Daniel Snijder, and Ryan van Huyssteun for assisting with the installation and/or monitoring of pitfall and funnel trap arrays. MNP management and the Environmental Management and Conservation Trust (EMCT) are thanked for assisting with transport and vehicle support when we experienced a mechanical breakdown. James Scheun, Dolf Botha, and Elize Botha are thanked for additional logistical support during the MNP surveys. Prinsloo M.J. Moolman donated the buckets used as pitfall traps, and Clint D. Wright provided the Coroplast® we used in the construction of drift fences. Kirsty J. Kyle conducted a pre-review on the original manuscript. TEP EKZNW management assisted with accommodation in the north of TEP. The TEP survey was conducted under permit number OP 13/2020 while the MNP surveys were conducted under a MNP management directive.

Literature Cited

Alexander, G.J., B. Maritz, D. Pietersen, J. Weeber, W. Conradie, and K.A. Tolley. 2022. *Lycophidion pygmaeum*. The International Union for the Conservation of Nature Red List of Threatened Species 2022, https://www.iucnredlist.org.

Branch, B. 1998. A Complete Guide to the Snakes and Other Reptiles of Southern Africa. Struik, Cape Town, South Africa.

Broadley, D.G. 1994. The genus *Scelotes* Fitzinger (Reptilia: Scincidae) in Mozambique, Swaziland, and Natal, South Africa. Annals of the Natal Museum 35: 237–259.

Bruton, M.N., and W.D. Haacke. 1980. The Reptiles of Maputaland. Pp 251–287 *In* Studies on the Ecology of Maputaland. Bruton, M.N., and K.H. Cooper. (Eds.). Rhodes University and Natal Branch of the Wildlife Society of Southern Africa.

Cape Town, South Africa.
Bruton, M.N., M. Smith, and R.H. Taylor. 1980. A brief history of human involvement in Maputaland. Pp. 432–459 *In* Studies on the Ecology of Maputaland. Bruton, M.N., and K.H. Cooper (Eds.). Rhodes University and Natal Branch of the Wildlife Society of Southern Africa. Cape Town, South Africa.
Direção Nacional de Áreas de Conservação (DNAC). 2010. Maputo Special Reserve Management Plan. DNAC, Ministry of Tourism, Maputo, Mozambique.
du Preez, L., and V. Carruthers. 2017. Frogs of Southern Africa. A Complete Guide. Struik Nature, Cape Town, South Africa.
Fernandes, R.S., G.E. Inteca, J.L. Williams, L. Muaves, and M. Xavier. 2021. Monitoring, tagging, and conservation of marine turtles in Mozambique. Annual Report 2019/2020, Centro Terra Viva, Maputo, Mozambique. 59 p.
Fischer, R.N., and C.J. Rochester. 2012. Pitfall-trap Surveys. Pp. 234–249 *In* Reptile Biodiversity: Standard Methods for Inventory and Monitoring. McDiarmid, R.W., M.S. Foster, G. Gyer, J.W. Gibbons, and N. Chernoff (Eds.). University of California Press, Los Angeles, California, USA.
FitzSimons, V.F.M. 1962. Snakes of Southern Africa. Prunell & Sons, Cape Town, South Africa.
Heinicke, M.P., M.H. Beidoun, S.V. Nielsen, and A.M Bauer. 2021. Phylogenetic analysis of "*Breviceps adspersus*" document *B. passmorei* Minter et al. 2017 in Limpopo Province, South Africa. Herpetology Notes 14:397–406.
Henderson, R.W., R. Powell, J. Martin, and P. Lopez. 2016. Arboreal and fossorial reptiles. Pp. 139–153 *In* Reptile Ecology and Conservation. Dodd, C.K., Jr. (Ed.). Oxford University Press, Oxford, UK.
Henley, M.D., R.M. Cook, A. Bedetti, J. Wilmot, A. Roode, C.L. Pereira, J. Almeida, and A. Alverca. 2023. A phased approach to increase human tolerance in elephant corridors to link protected areas in southern Mozambique. Diversity 15(1):85. http://doi.org/10.3390/d15010085.
Howland, B., D. Stojanovic, I.J. Gordon, A.D. Manning, D. Fletcher, and D.B. Lindenmayer. 2014. Eaten out of house and home: impacts of grazing on ground-dwelling reptiles in Australian grasslands and grassy woodlands. PLoS ONE 9(12):e105966. https://doi.org/10.1371/journal.prone.0105966.
Jansen, A., and M. Healey. 2003. Frog communities and wetland condition: relationships with grazing by domestic livestock along an Australian floodplain river. Biological Conservation 109:207–219.
Jordaan, P.R. 2020. Geographical distribution Cordylidae *Chamaesaura macrolepis* (Cope 1862) Large Scale Grass Lizard. African Herp News 75:59–60.
Jordaan, P.R. 2021a. Geographical distributions *Scelotes bidigitattus* FittzSimons 1930/ *Scelotes fitzsimonsi* Broadley 1994/ *Scelotes vestigifer* Broadley. African Herp News 78:61–66.
Jordaan, P.R. 2021b. The establishment of a multifaceted Nile Crocodile, *Crocodylus niloticus* Laurenti, 1768, monitoring program in Maputo Special Reserve (Maputo Province, Mozambique) with preliminary notes on population status (Reptilia: Crocodylidae). Herpetology Notes 14:1155–1162.
Jordaan, P.R. 2022. Practical considerations for conducting structured herpetological surveys in the presence of potentially dangerous wildlife: notes from fieldwork in protected areas across Maputaland. African Herp News 79:17–31.
Jordaan, P.R., and A. Wilken. 2022. Fornasini's Blind Snake *Afrotyphlops fornasinii* (Bianconi, 1849): morphometric measurements, maximum size records, and habitat associated abundance. African Herp News 81:14–16.
Jordaan, P.R., J.S.R. Cutler, and D Snijder. 2020. Geographical distributions Lamprophiidae *Lycophidion pygmaeum* Broadley 1996 Pygmy Wolf Snake. African Herp News 74:88–91.
Jordaan, P.R., T.R. Dando, C.C. Hanekom, A. Wilken, and X. Combrink. 2023. Testing post-fire bias in herpetofaunal capture rates during a short pitfall and funnel trap survey in Tembe Elephant Park, KwaZulu-Natal, South Africa. Herpetology Notes 16:127–133.
Jordaan, P.R., T. Nangammbi, C.C. Hanekom, X, Combrink, and J. Measey. 2025. Quantified variations in pre- and post-fire fossorial herpetofaunal community structure of a savanna habitat in Tembe Elephant Park, South Africa. Herpetology Notes 18:1011–1020.
Jordaan, P.R., J.C.A. Steyl, C.C. Hanekom, and X. Combrink. 2020. Fire-associated reptile mortality in Tembe Elephant Park, South Africa. Fire Ecology 16:3. http://doi.org/10.1186/s42408-019-0066-4.
Jordaan, P.R., A. Wilken, and X. Combrink. 2024. The impact of *Eucalyptus* plantations on herpetofaunal diversity, Maputo National Park, Mozambique.

African Journal of Herpetology 73:48–60.

Marais, J. 2022. A Complete Guide to the Snakes of Southern Africa. Penguin Randon House, Cape Town, South Africa.

Matthews, W.S., A.E. van Wyk, N. van Rooyen, and G.A. Botha. 2001. Vegetation of the Tembe Elephant Park, Maputaland, South Africa. South African Journal of Botany 67:573–593.

McCauley, D.J., F. Keesing, T.P. Young, B.F. Allan, and R.M. Pringle. 2006. Indirect effects of large herbivores on snakes in an African savanna. Ecology 87:2657–2663.

Measey, G.J., A.J. Armstrong, and C.C. Hanekom. 2009. Subterranean herpetofauna show a decline after 34 years in Ndumu Game Reserve, South Africa. Oryx 43:284–287.

Nasseri, N. A., L.D. McBrayer, and B.A. Schulte. 2010. The impact of tree modification by African Elephant (*Loxodonta africana*) on herpetofaunal species richness in northern Tanzania. African Journal of Ecology 49:133–140.

Pooley, A.C., E. Pooley, F.W. Hadley, and C. Gans. 1973. Ecological aspects of the distribution of subsoil herpetofauna in Ndumu Game Reserve. Annals of the Carnegie Museum 44:103–115.

Pretorius, W.W. 2019. Ecology and calling behavior of the anurans of northern Zululand, South Africa. M.Sc. Thesis, North-west University, Potchefstroom, South Africa. 112 p.

Reeder, J.E. 2019. Amphibians of northern KwaZulu-Natal: a phylogenetic study. M.Sc. Thesis, North-west University, Potchefstroom, South Africa. 102 p.

Russell, C., and C.T. Downs. 2012. Effect of land use on anuran species composition in north-eastern KwaZulu-Natal, South Africa. Applied Geography 35:247–256.

Smith, R.J., J. Easton, B.A. Nhancale, A.J. Armstrong, J. Culverwell, S.D. Dlamini, P.S. Goodman, L. Loffler, W.S. Matthews, A. Monadjem, et al. 2008. Designing a transfrontier conservation landscape for the Maputaland Centre of Endemism using biodiversity, economic and threat data. Biological Conservation 141:2127–2138

South African National Biodiversity Institute (SANBI). 2020. Species environmental assessment guideline. Guidelines for the implementation of the terrestrial fauna and terrestrial flora species protocols for environmental impact assessments in South Africa. Version 1.2020. South African National Biodiversity Institute, Pretoria, South Africa. 236 p.

Tello, J.L.P.L. 1973. Reconhecimento Ecologico da Reserva dos Elefantes do Maputo. Revistade Veterinaria Moçambicana. 5/6:1–186.

Tembe Elephant Park (TEP). 2009. Tembe Elephant Park: integrated management plan: 2009–2013. Version 1.0. Ezemvelo KwaZulu-Natal Wildlife, Pietermaritzburg, South Africa. 70 p.

Willson, J.D. 2016. Surface-dwelling reptiles. Pp 125–138 *In* Reptile Ecology and Conservation. Dodd, C.K., Jr. (Ed.). Oxford University Press, Oxford, UK.

Supplemental Information: http://www.herpconbio.org/Volume_21/Issue_1/Jordaan_etal_2026_Suppl

Philip R. Jordaan studied nature conservation through the Tshwane University of Technology. He has conducted multiple herpetological assessments throughout South Africa and Mozambique and is a founding Director of Crocodile Conservation South Africa (NPC). Currently, he is on assignment through African Ecological Conservation Projects (Pty) Ltd to Mozambique Wildlife Alliance as a Field Ecologist in Cabo Delgado Province, northern Mozambique. Philip also works with students and early career biologists and conservationists to facilitate practical fieldwork through African Biodiversity Research Expeditions (Pty) Ltd. (Photographed by Erik Schram).

Cathariné C. Hanekom holds a M.S. in Protected Landscape Management from the University of Greenwich. She has worked for Ezemvelo KwaZulu-Natal Wildlife for 30 y and has extensive experience in field surveys of both fauna and flora. She translates these data into management, vegetation, and game recommendations for the protected areas in which she works. Cathariné also compiles management plans for a range of faunal and flora species, including elephants and lions, as well as natural resources harvested from protected areas. She is based in Tembe Elephant Park, Maputaland, as the District Ecologist. (Photographed by Cathariné C. Hanekom).

Miguel Gonçalves studied Marine Biology at Eduardo Mondlane University, Maputo, Mozambique. He was appointed as the Warden of both Ponta du Ouro Partial Marine Reserve in 2008, and Maputo Special Reserve in 2017. He is the current Warden of Maputo National Park following the merger of the two protected areas. Miguel has been involved in coral reef and marine turtle conservation and monitoring programs and in 2022 he received the Tusk Award for Conservation in Africa. (Photographed by Sarah Watson).