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Reptiles of the King Abdulaziz Royal Nature Reserve, east-central Saudi Arabia: insights and conservation implications

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***Abstract.*—The distribution of herpetofauna on the Arabian Peninsula is generally poorly known, particularly in Saudi Arabia. The King Abdulaziz Royal Nature Reserve (KARNR) in east-central Saudi Arabia is in an area predicted to have high reptile species richness, yet there is no baseline reptile checklist for the reserve. Knowing which species occur within a protected area is vital for ensuring that conservation strategies and long-term monitoring are effective. Here, we provide the first detailed list of reptile fauna occurring in the KARNR. This study recorded a total of 31 species from 1,551 observations, including 25 lizards and six snakes. A desktop study identified three additional species, bringing the total number of herpetofaunal species known in the KARNR to 34. Two of the species found in the reserve are of conservation concern: *Uromastyx aegyptia* (VU) and *Tropiocolotes wolfgangboehmei* (DD). Through species accumulation curves we were able to determine that the sampling methods implemented during the survey were adequate, and we predicted that the species richness of the reserve is likely as much as 38 species. Prior to this study, only 82 reptile records (30 species) were known from the study area, so we add a significant number of new records to the reserve and an additional four species that were previously unknown from the region.**

Keywords. Arabian Peninsula, baseline, iNEXT, protected area, species accumulation curves, species richness, Squamata, *Tropiocolotes wolfgangboehmei*, *Uromastyx aegyptia*

Citation: van Huyssteen R, Petford MA, Burger M, Šmíd J, Alzahrani AS, Alowaifeer AM, Mottram P, Gaugris JY. 2024. Reptiles of the King Abdulaziz Royal Nature Reserve, east-central Saudi Arabia: insights and conservation implications. *Amphibian & Reptile Conservation* 18(1&2): 91–106 (e335).

Accepted: 2 September 2024; **Published:** 25 November 2024

Introduction

Reptile species richness on the Arabian Peninsula is highest in the mountainous regions along the south-western, southern, and eastern parts of the peninsula (Carranza et al. 2021; Šmíd et al. 2021). However, the central desert regions also have relatively high species richness and phylogenetic diversity (Cox et al. 2012; Šmíd et al. 2021; Tamar et al. 2023). The Kingdom of Saudi Arabia, which covers most of the Arabian Peninsula, is well known for its large expansive deserts and a number of regional inventories of reptiles have been compiled over the past few decades (i.e., Al Sadoon et al. 2016, 2017; Aloufi et al. 2021, 2022; Alshammari and Busais 2020; Alshammari et al. 2017; Alshammari and Ibrahim 2015; Aloufi and Amr 2015; Cunningham 2010; Farag and Banaja 1980; Tilbury 1998). Despite these inventories, large areas of Saudi Arabia are poorly surveyed for reptiles at the landscape scale, so our current knowledge of the distribution and community composition of Saudi Arabia's reptiles is inadequate (Šmíd et al. 2021).

The King Abdulaziz Royal Nature Reserve (KARNR) in east-central Saudi Arabia was established in 2018 and is one of seven royal reserves in the country (https://www.karnr.gov.sa/). The reserve covers a heterogenous landscape of just over 28,000 km^2, and this region is predicted to have high terrestrial reptile species richness (Alatawi et al. 2020; Ficetola et al. 2013; Šmíd et al. 2021). However, there have been no dedicated surveys on the reptile species richness of the area. The lack of such inventories in protected areas is detrimental to reptile conservation as there are no baseline data to inform conservation strategies and long-term monitoring methods in the reserve (Margules and Pressey 2000; Mihoub 2017).

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This study aimed to provide an adequate baseline of reptile species richness in the KARNR. To achieve this, we conducted field work on five occasions between November 2022 and October 2023 for a total of 46 days, which equated to 139 person-days in the field. A desktop study was also conducted to identify any reptile species previously recorded from the area. We tested the adequacy of our survey effort using species accumulation curves and estimated diversity indices.

Materials and Methods

Study Area

The KARNR is situated in east-central Saudi Arabia. It is located between the northern Riyadh region and northwestern Eastern Province and covers an area of just over 28,000 km^2 (Fig. 1). Our study area was the KARNR plus a 10 km buffer around the boundary of the reserve. According to the Köppen-Geiger classification, this region is categorized as a hot desert (Peel et al. 2007). The major geomorphological features of the study area are the Al Summan plateau in the north of the reserve, the Ad Dahna sand desert that crosses the reserve nearly transversely in the middle, and the Tuwaiq Escarpment, a mountain ridge that cuts through the southern part of the reserve (Almalki et al. 2022; Vincent 2008). The influence of these sandy and rocky formations has resulted in a high habitat heterogeneity for the region, with rocky areas (such as escarpments and rock outcrops), open plains (stoney and gravel plains), dunes (mobile and vegetated dunes), and wetland areas and drainage lines (wadis and rawdhats) (Fig. 2). A general north/south moisture gradient is evident from the vegetation and plant communities in the study area, with the southern areas having more trees and rawdhat areas (Ghazanfar and Fisher 1998).

Fig. 2. Several landscape features of the King Abdulaziz Royal Nature Reserve, showing some of the habitat diversity in the region.

Methods

Field surveys. Three primary field surveys were carried out for 21 days from 23 November to 13 December 2022, 18 days from 3 to 20 March 2023, and eight days from 28

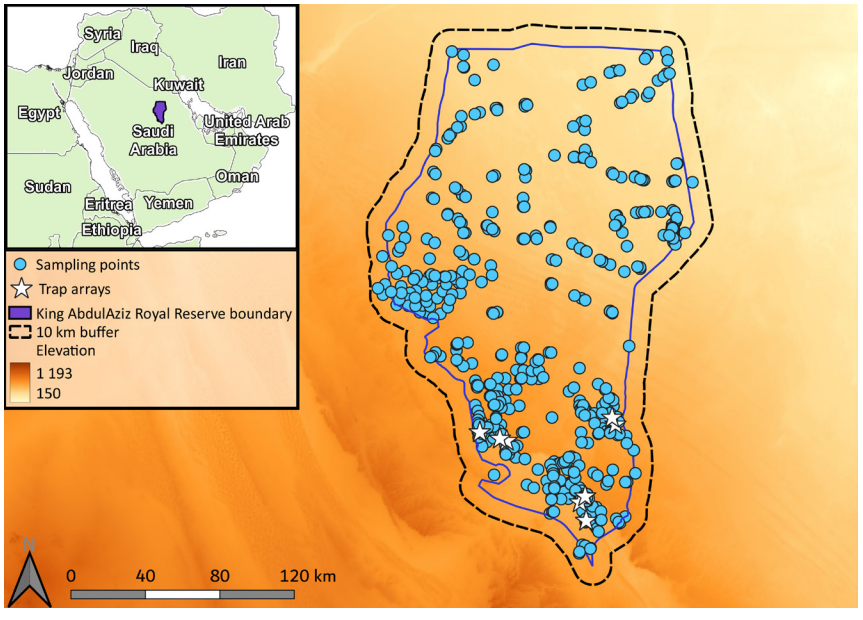

Fig. 1. The King Abdulaziz Royal Nature Reserve study area and its location in the Arabian Peninsula. Blue dots show sampling points visited during the 2022/23 survey, and white stars show reptile trap array locations.

September to 5 October 2023. Two opportunistic surveys were also conducted for a five-day period, which formed part of larger scale rapid biodiversity overviews and were more limited in effort than the three primary surveys. One was from 17 to 21 February 2023 and another was from 8 to 12 June 2023. Collectively, these covered a total of 57 survey-days and 139 person-days. Sampling methods during the field surveys included active searching (both diurnal and nocturnal, see below) and trapping (6 March until 19 March 2023). Observations recorded by team members surveying other taxa were also included as supplementary records. The February 2023 opportunistic survey also targeted wetland areas after a good rain season to check for the occurrence of amphibians in the study area. The June 2023 opportunistic survey was conducted during a hot period of the year and had a specific focus on nocturnal active searches. Reptiles were recorded to the species level when possible. Occasionally some individuals could only be identified to genus when species assignment was uncertain. When feasible, DNA barcoding was conducted to aid in the identification in these instances. For each record, a GPS location (with an average accuracy of 5 m) was taken using Garmin Montana i750 GPS units, and specimen abundance was noted.

Active searching was conducted at 374 specific point locations across the reserve (Fig. 1). These points were selected by overlaying a 1 km sampling grid across the study area and using a multistage, stratified, semi-random sampling approach. The northern section of the reserve, Al Summan, was only surveyed during November–December 2022 and September 2023 due to logistical constraints. The southern section of the reserve was surveyed during all sampling seasons. Diurnal surveys were conducted between 0600 and 1900 h, while nocturnal surveys took place between 1900 and 2300 h.

Eight trap arrays were deployed within the study area. The placement of trap arrays was limited to areas near main roads due to logistical convenience. Each trap array consisted of three 10 m drift fences of robust plastic, arranged in a linear design as described by Mendes et al. (2015), together with four 20 L buckets sunk into the ground as pitfall traps, and six wire-mesh funnel traps positioned on each side of the drift fence between the pitfall traps (Fig. 3). The funnel traps were covered with shade netting to provide shelter for captured animals, while moistened leaf-litter and cloth were added to the buckets to provide shelter and moisture in the pitfall traps. These traps were checked daily for captured animals. The eight trap arrays were installed for 13 nights, equating to 104 trap array-nights.

A desktop survey was also conducted to consolidate historical reptile records for the study area. This was achieved by consulting various literature sources (e.g., Aloufi et al. 2019; Al-Sadoon 1988; Al-Sadoon 1989; Gasperetti 1988; Kordges 1998; Salvador 1982; Šmíd et al. 2021) and online databases (e.g., Global Biodiversity Information Facility at http://GBIF.org and iNaturalist at http://inaturalist.org). All photographic records obtained during the 2022/23 survey were uploaded to iNaturalist and these are available in Supplemental Table S1.

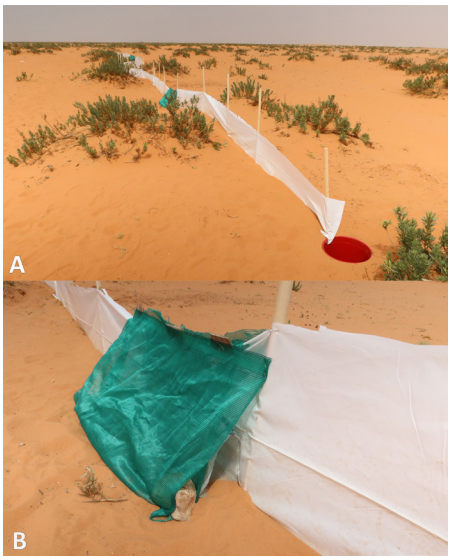

Fig. 3. (A) An example of a trap array showing drift fence and pitfall trap. (B) Detail of a funnel trap with shade netting cover.

DNA sequencing. Some species of Arabian reptiles are challenging to identify based on morphological characters alone. We therefore sequenced a short fragment of one mitochondrial gene and applied DNA barcoding methods to verify the identification in the field. Of the species recorded during the surveys, we DNA barcoded members of the following genera: *Acanthodactylus* and *Mesalina* (both Lacertidae); *Pseudotrapelus* and *Trapelus* (both Agamidae), *Hemidactylus* and *Stenodactylus* (both Gekkonidae), *Scincus* (Scincidae), and *Ptyodactylus* (Phyllodactylidae). Tissue samples were obtained by taking a small piece of tail. All samples were preserved in 96% ethanol and DNA was extracted using the Qiagen DNeasy Blood and Tissue Kit (Qiagen, Valencia, California, USA) following the manufacturer's protocol. We PCR-amplified and sequenced the ribosomal 12S rRNA (12S) region of the mitochondrial DNA for all groups except the agamids, for which we sequenced the 16S rRNA (16S). Primers and PCR conditions are detailed in Šmíd et al. (2021). The PCR products were sequenced from both directions at Macrogen (Amsterdam, the Netherlands), and raw sequence data were edited and assembled in Geneious v.11 (Kearse et al. 2012). The identification of each specimen was confirmed using the BLAST algorithm of the National Center for Biotechnology Information website (https://blast.ncbi.nlm.nih.gov/).

Species Accumulation Curves

Total survey. To assess our survey effort in the KARNR, we used species accumulation curves calculated in R (R

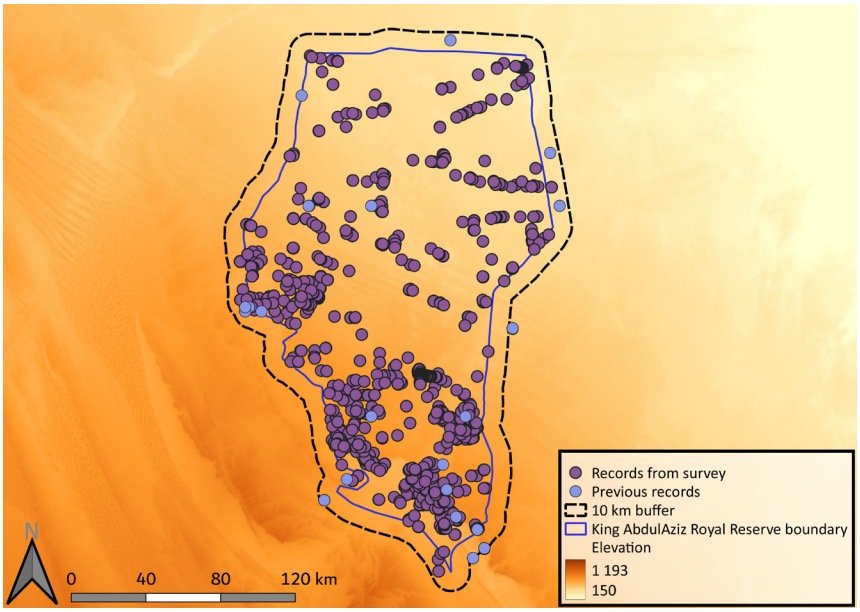

Fig. 4. Records of reptiles found during the 2022/23 survey period (purple circles) and from the desktop study (blue circles) in the King Abdulaziz Royal Nature Reserve.

Core Team 2022) using the R studio console (RStudio team 2022) with the iNEXT package (Hsieh et al. 2016). Species accumulation curves were plotted and extrapolated to double the original survey effort (Hseih et al. 2016), and the order of the observations made during the survey were randomized 100 times in a bootstrap fashion. The estimated species richness was calculated in iNEXT along with the standard error and lower and upper confidence levels. Shannon and Simpson diversity indices were also calculated. Four broad-scale reptile habitat types were identified for the KARNR: (1) Dunes and dune valleys, (2) Hills, outcrops, and escarpments, (3) Plains, and (4) Wadis, rawhdats, and pans. These habitat types were defined based on vegetation and topographic characteristics. For each habitat type, predictive species accumulation curves were provided to assess the sampling effort for each of the broad habitat types.

The survey species richness was then evaluated in terms of completeness according to the iNEXT estimated species richness. A percentage of the completeness score was calculated as SurveySR/iNEXT Estimated SR x 100. Any result greater than 90% is regarded as "close to completely surveyed," since it can be unlikely that all species could be recorded during a finite survey (Chao and Jost 2012; Moreno and Halffter 2001; Thompson et al. 2007). Note that the value calculated is an estimate based on the species accumulation curve, and therefore dependent on the sampling effort.

Survey effort was also assessed for each habitat type to evaluate diversity at the broad-scale habitat level. For this, the vegetation class for each species record was extracted from a vegetation layer generated for the suite of studies conducted for the present project (Van Rooyen et al. 2023) using QGIS 3.22.8 (QGIS Development Team 2023). Each vegetation type class represented in the reserve was then grouped into broad habitat units of Dunes and dune valleys; Plains; Outcrops, hills and escarpments; and Wadis, rawhdats and pans. The methods above were used to create species accumulation curves and estimate species richness.

Results

A total of 1,551 reptile observations of 31 species were made during the 2022/2023 survey period, composed of 25 lizards and six snakes (Table 1, Supplemental Table S1, Figs. 4–9). Four species had not been previously recorded in the area: *Trapelus agnetae*, *Hemidactylus granosus*, *Mesalina saudiarabica*, and *Diplometopon zarudnyi*. The desktop study of published and online sources produced 82 records of 30 species, three of which were not recorded during our survey: *Platyceps rhodorachis*, *Myriopholis macrorhyncha*, and *Walterinnesia morgani*. Therefore, the total known reptile species richness for the KARNR is currently 34 species.

Most reptile observations were recorded via active searching (n = 1,400). Fifty-three individuals were captured by trap arrays, with the most common being *Acanthodactylus opheodurus* (n = 11). The remaining 91 records were all incidental. The most common species encountered was *Bunopus tuberculatus* (n = 579), followed by *Uromastyx aegyptia* (n = 367). Two species were recorded only once during the survey: *Acanthodactylus hardyi* and *Echis coloratus* (Table 1).

Two species of conservation concern were found within the reserve borders: *U. aegyptia* (Vulnerable) and *Tropiocolotes wolfgangboehmei* (Gekkonidae; Data Deficient) (IUCN 2023). Although *U. aegyptia* was very common throughout the reserve, only two *T. wolfgangboehmei* were found. One of the localities for *T.*

Table 1. Checklist and abundance of reptile species recorded in the King AbdulAziz Royal Nature Reserve. The International Union for Conservation of Nature (IUCN 2023) listings of conservation status refer to the following categories: Not Evaluated (NE), Least Concern (LC), Data Deficient (DD), Vulnerable (VU), and Endangered (EN).

Scientific name	Common name	IUCN status	Number of observations	Recorded during survey	Recorded prior to survey
SAURIA	**Lizards**				
Family Agamidae					
Phrynocephalus arabicus	Arabian Toad-headed Agama	LC	26	Y	Y
Pseudotrapelus tuwaiqensis	Tuwaiq Agama	NE	2	Y	Y
Trapelus agnetae	Northern Arabian Plain Agama	LC	4	Y	N
Trapelus ruderatus	Olivier's Agama	LC	4	Y	Y
Uromastyx aegyptia	Egyptian Spiny-tailed Lizard	VU	367	Y	Y
Family Gekkonidae					
Bunopus tuberculatus	Baluch Ground Gecko	LC	579	Y	Y
Cyrtopodion scabrum	Rough-tailed Gecko	LC	4	Y	Y
Hemidactylus granosus	West Arabian Half-toed Gecko	NE	5	Y	N
Stenodactylus doriae	Middle Eastern Short-fingered Gecko	LC	44	Y	Y
Stenodactylus slevini	Slevin's Short-fingered Gecko	LC	16	Y	Y
Trigonodactylus arabicus	Arabian Web-footed Sand Gecko	LC	13	Y	Y
Tropiocolotes wolfgangboehmei	Wolfgang's Sand Gecko	DD	2	Y	Y
Family Phyllodactylidae					
Ptyodactylus cf. *hasselquistii*	Hasselquist's Fan-footed Gecko	LC	107	Y	Y
Family Lacertidae					
Acanthodactylus boskianus	Bosc's Fringe-fingered Lizard	LC	24	Y	Y
Acanthodactylus hardyi	Hardy's Fringe-fingered Lizard	NE	1	Y	Y
Acanthodactylus opheodurus	Snake-tailed Fringe-fingered Lizard	LC	54	Y	Y
Acanthodactylus schmidti	Schmidt's Fringe-fingered Lizard	LC	57	Y	Y
Mesalina brevirostris	Short-nosed Desert Lizard	LC	102	Y	Y
Mesalina lineage 4	Small Spotted Desert Racer	-	46	Y	Y
Mesalina saudiarabica	Arabian Short-nosed Desert Lizard	NE	3	Y	N
Family Scincidae					
Chalcides ocellatus	Ocellated Skink	LC	8	Y	Y
Scincus mitranus	Arabian Sandfish	LC	12	Y	Y
Scincus conirostris	Sandfish Skink	NE	12	Y	Y
Family Trogonophidae					
Diplometopon zarudnyi	Zarudny's Worm Lizard	LC	23	Y	N
Family Varanidae					
Varanus griseus	Desert Monitor	LC	7	Y	Y

SERPENTES	Snakes				
Family Boidae					
Eryx jayakari	Arabian Sand Boa	LC	2	Y	Y
Family Colubridae					
Platyceps rhodorachis	Braid Snake	LC	0	N	Y
Spalerosophis diadema	Diadem Snake	LC	5	Y	Y
Family Elapidae					
Walterinnesia morgani	Black Desert Cobra	LC	0	N	Y
Family Leptotyphlopidae					
Myriopholis macrorhyncha	Beaked Thread Snake	LC	0	N	Y
Family Psammophiidae					
Malpolon moilensis	Hooded Malpolon	LC	6	Y	Y
Psammophis schokari	Afro-Asian Sand Snake	LC	4	Y	Y
Family Viperidae					
Cerastes gasperettii	Arabian Horned Viper	LC	11	Y	Y
Echis coloratus	Palestine Saw-scaled Viper	LC	1	Y	Y
Total observations and species counts			**1,551**	**31**	**30**
Total species for KARNR				**34**	

wolfgangboehmei was inside the 10 km buffer zone from a known site, whereas the other was inside the reserve and represents a new locality record for this species.

DNA Barcoding

We DNA barcoded a total of 95 samples in the families Agamidae (four samples), Gekkonidae (13 samples), Lacertidae (59 samples), Phyllodactylidae (seven samples), and Scincidae (12 samples). The results mostly confirmed our field identifications. However, two species were misidentified in the field and were only revealed by the DNA analysis. These were one specimen of *Acanthodactylus hardyi* and three specimens of *Mesalina saudiarabica*, both from the vicinity of the Ad Dahna sand stretch. It is important to note the majority of *Mesalina brevirostris* specimens were not DNA barcoded, so some of these may be incorrectly identified as *M. saudiarabica*. Details on the DNA barcoding results along with GenBank accessions of the newly sequenced samples are given in Supplemental Table S2.

Species Accumulation Curves

The predictive species accumulation curve indicates that the sampling methods employed during the field surveys were adequate, with the curve reaching an asymptote (Fig. 10) and an estimated 97.89% of reptile species being recorded, based on the iNEXT completeness score (Table 2). The species accumulation curve predicts that the species richness for the KARNR is between 31 and 38 species (LCL = 31; UCL = 37.84; Table 2).

Dunes and dune valleys are the least well sampled of the broad habitat units, with the accumulation curve not reaching an asymptote (Fig. 11) and an estimated 63.75% of the reptile species being recorded based on the iNEXT completeness score (Table 2). Plains are relatively well sampled, but the iNEXT completeness score of 88.75% suggests that additional species are likely to be found in this area, with an estimated species richness between 21 and 38 (LCL = 21.0; UCL = 38.05). Wadis, rawhdats, and pans also appear to be well sampled with an iNEXT completeness of 94.93%. Hills, outcrops, and escarpments are the most well sampled habitat type with iNEXT completeness scores of over 98% and accumulation curves approaching asymptotes (Table 2; Fig. 11).

Discussion

There are now 34 species of reptiles confirmed to occur within the KARNR. Thirty-one of these species were found during our survey, four of which had not previously been recorded in this area. This study contributes a substantial number of observations for the region, with 1,550 individual records across the reserve, compared

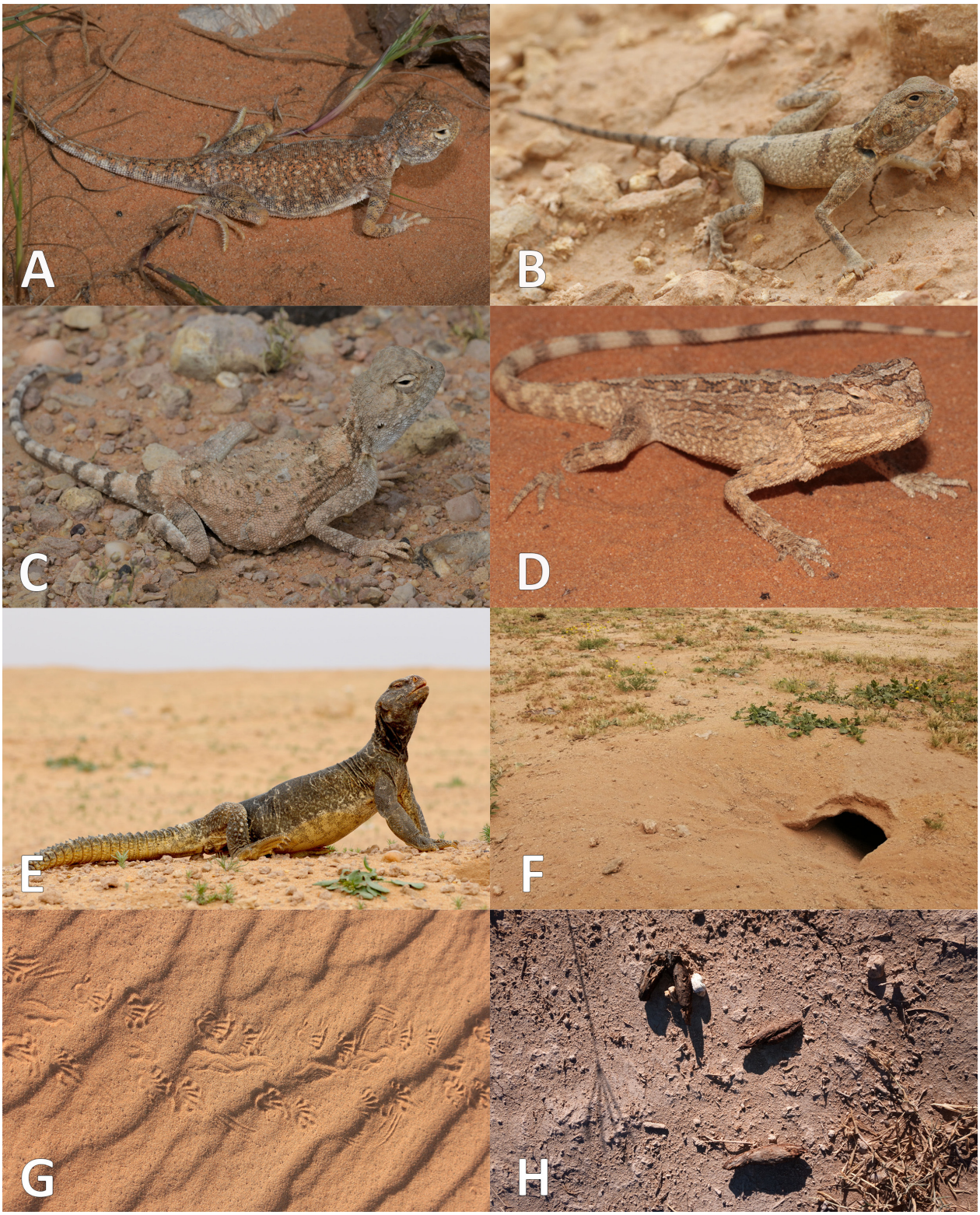

Fig. 5. (A) *Phrynocephalus arabicus*, (B) *Pseudotrapelus tuwaiqensis*, (C) *Trapelus agnetae*, (D) *Trapelus ruderatus*, (E) *Uromastyx aegyptia*, (F) *Uromastyx aegyptia* burrow, (G) *Uromastyx aegyptia* tracks, (H) *Uromastyx aegyptia* scat.

to only 82 known prior to our survey. The number of species recorded in the reserve is expected to increase as taxonomic revisions are completed and as further surveys are conducted. The information generated here will aid the conservation efforts of the reserve, provide a baseline for long-term monitoring, and inform further regional research and conservation assessments.

The 1,551 records generated for the reserve add a substantial number of observations not only for KARNR, but also for the whole of the Arabian Peninsula, with an

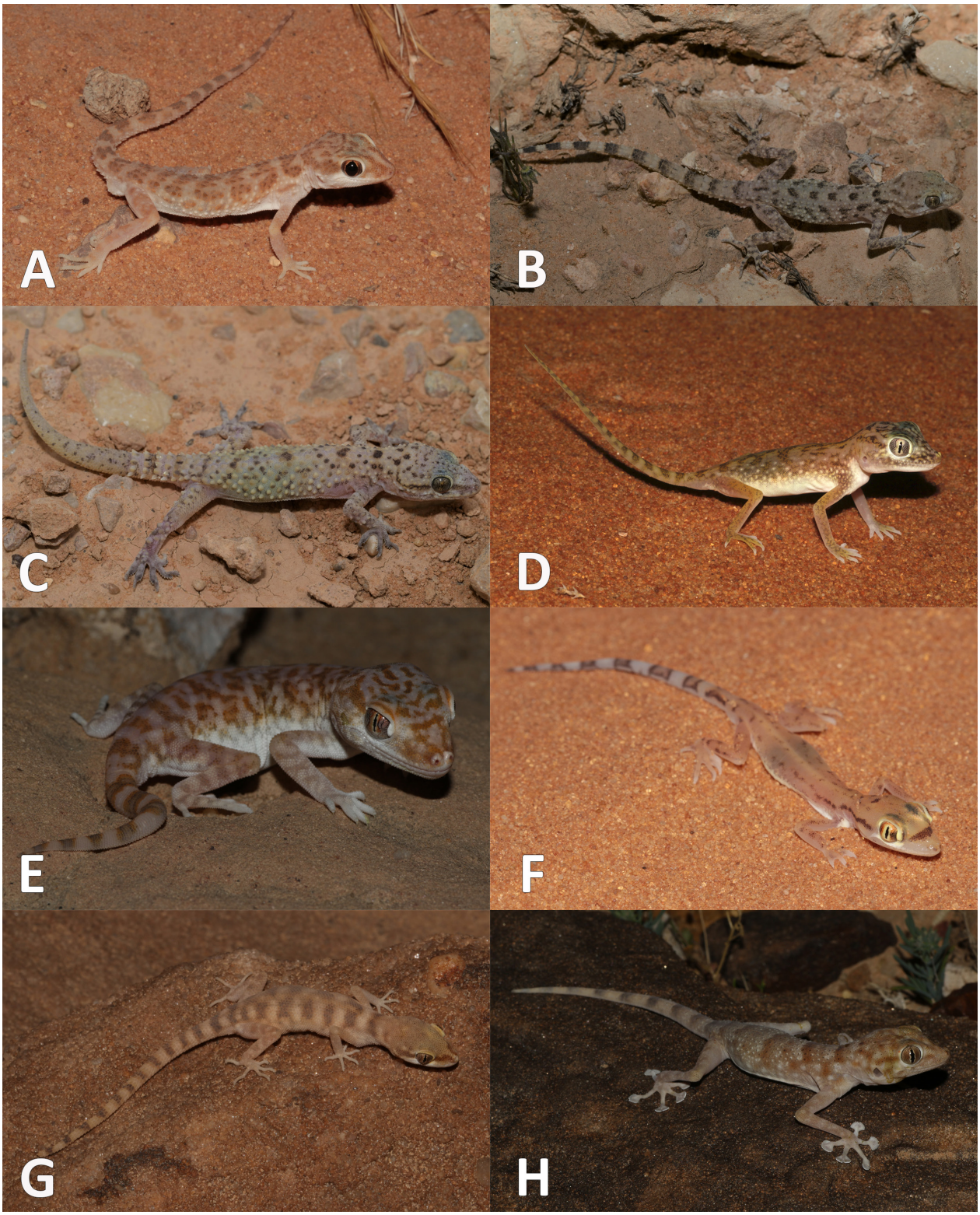

Fig. 6. (A) *Bunopus tuberculatus*, (B) *Cyrtopodion scabrum*, (C) *Hemidactylus granosus*, (D) *Stenodactylus doriae*, (E) *Stenodactylus slevini*, (F) *Trigonodactylus arabicus*, (G) *Tropiocolotes wolfgangboehmei*, (H) *Ptyodactylus* cf. *hasselquistii*.

8.59% increase based on 18,053 records for the region as of 2021 (Šmíd et al. 2021). Having a baseline of reptile species diversity (richness and abundance) is important from a conservation perspective, as the data can be used to monitor changes over time (Maritz et al. 2016). Without such diversity metrics, the decay of richness and abundance, potentially signalling local extinction events (Cressey et al. 2015; Zipkin et al. 2020), will go undetected and the "shifting baseline" syndrome is likely to take effect (Pauly 1995; Soga and Gaston 2018). For KARNR, this established baseline places conservation managers and stakeholders in a position to monitor future

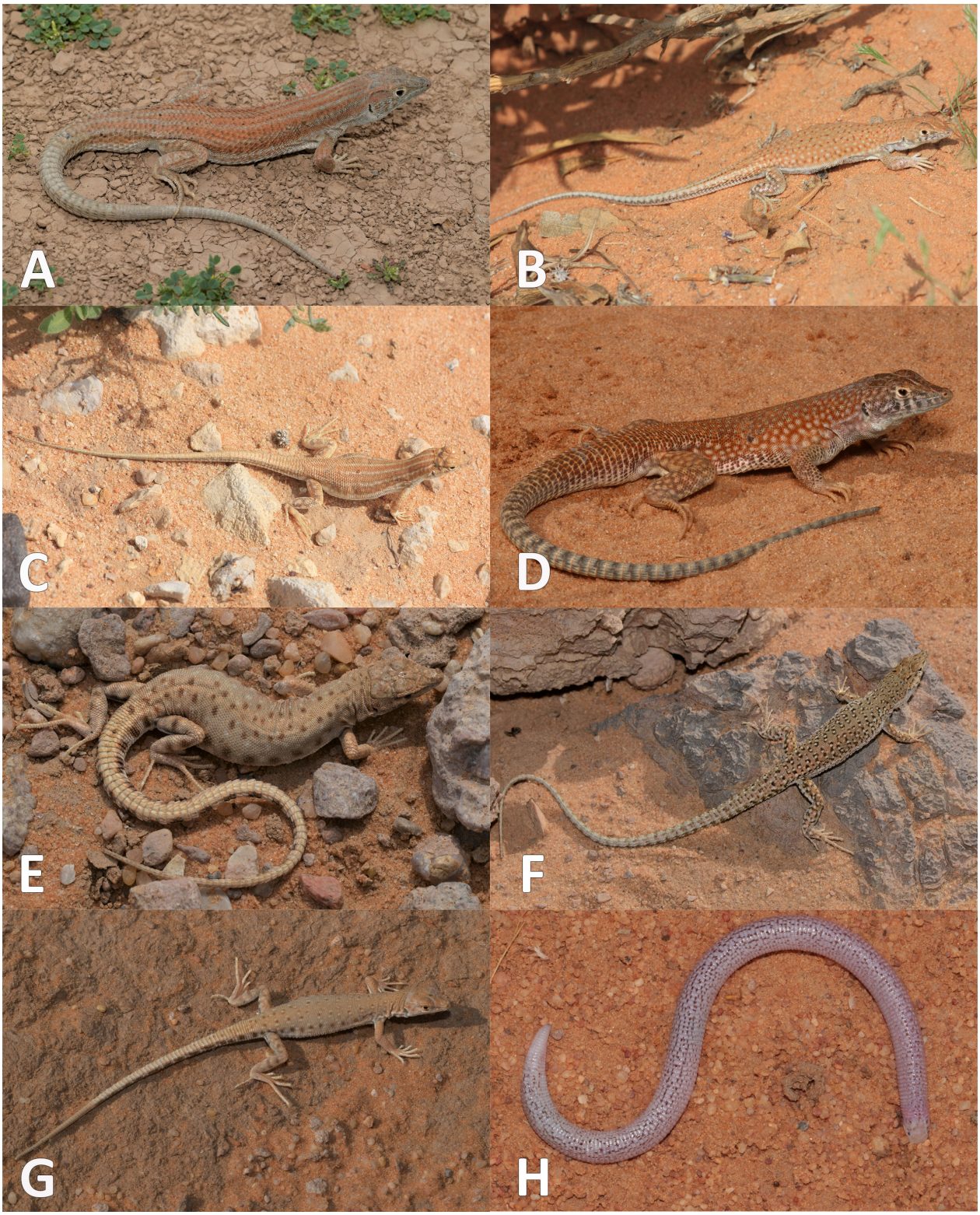

Fig. 7. (A) *Acanthodactylus boskianus*, (B) *Acanthodactylus hardyi*, (C) *Acanthodactylus opheodurus*, (D) *Acanthodactylus schmidti*, (E) *Mesalina brevirostris*, (F) *Mesalina* lineage 4, (G) *Mesalina saudiarabica*, (H) *Diplometopon zarudnyi*.

trends in the reserve. In addition, this survey provides a benchmark for comparisons to other reserves in the Arabian Peninsula.

The KARNR lies in an area predicted to have high reptile species richness of between 20 to 40 species (Alatawi et al. 2020; Šmíd et al. 2021). The 34 species confirmed to occur in the reserve are within these bounds of the richness projection, but more species may potentially occur here, particularly in the southern areas (Alatawi et al. 2020; Šmíd et al. 2021). Species richness was not evenly distributed over the different broad habitat types. Hills, outcrops, and escarpments had the highest

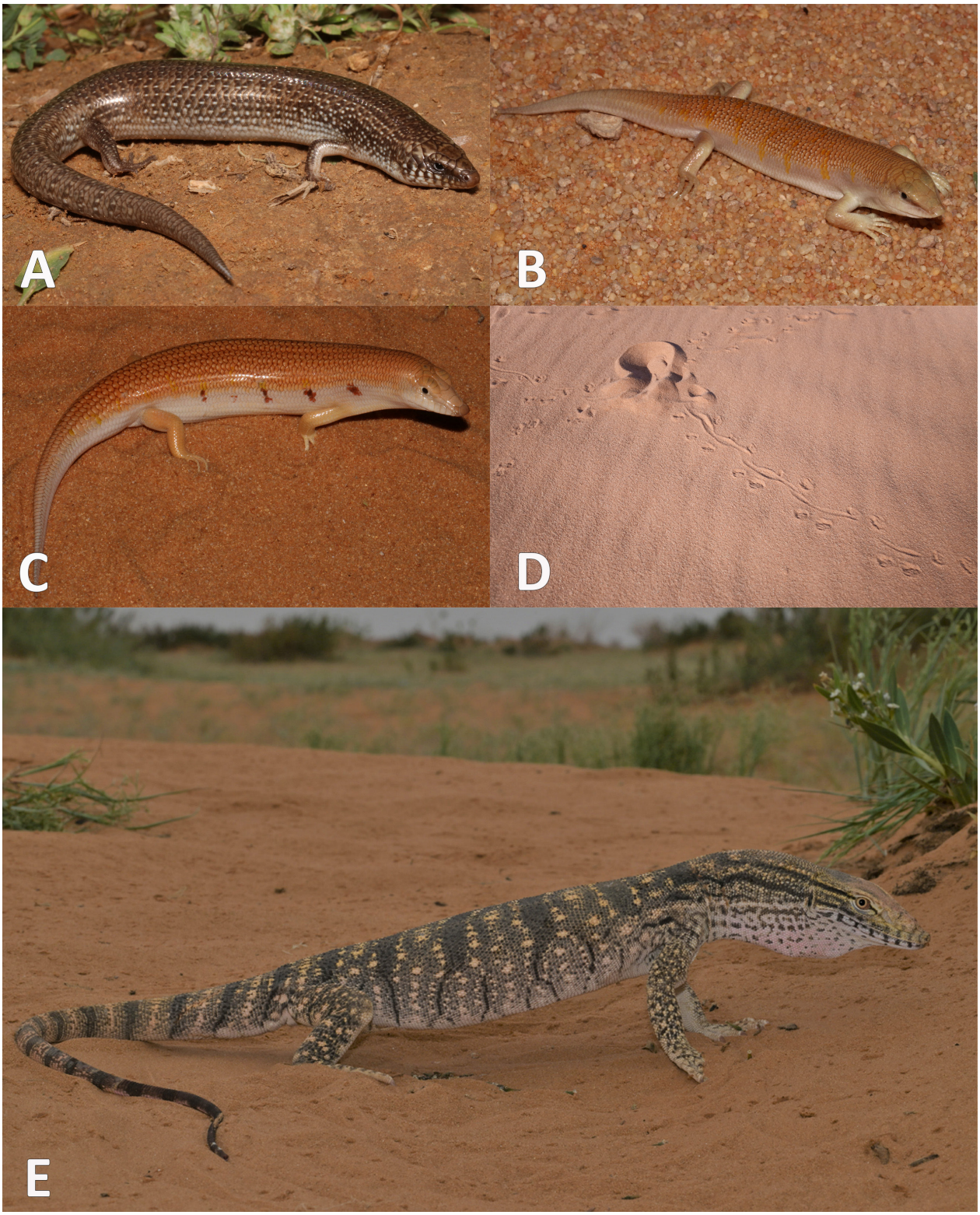

Fig. 8. (A) *Chalcides ocellatus*, (B) *Scincus mitranus*, (C) *Scincus conirostris*, (D) *Scincus conirostris* tracks, (E) *Varanus griseus*.

diversity in terms of species richness, followed by Wadis and rawdhats, and Plains. Dunes and dune valleys had the lowest species richness. This trend can be attributed to the habitat heterogeneity hypothesis, which states that regions with higher habitat heterogeneity have higher species diversity (MacArthur and MacArthur 1961).

Additional surveys within the reserve are likely to yield new species, but several of the species encountered during the surveys are also undergoing taxonomic revision. For example, tentative molecular analyses indicate that more than one species of the *Ptyodactylus hasselquistii* complex may occur within the KARNR,

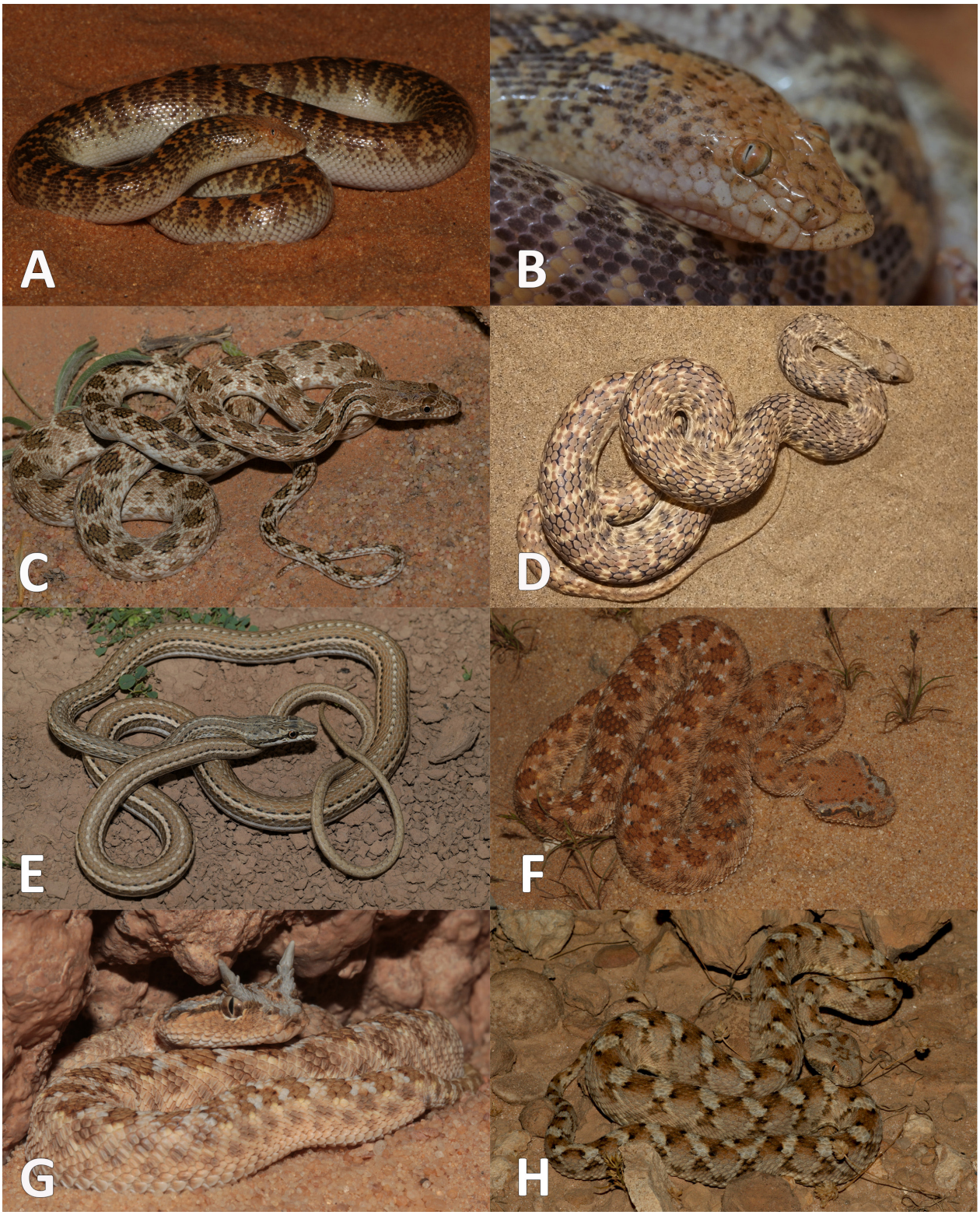

Fig. 9. (A) *Eryx jayakari*, (B) *Eryx jayakari*, (C) *Spalerosophis diadema*, (D) *Malpolon moilensis*, (E) *Psammophis schokari*, (F) *Cerastes gasperettii*, (G) *Cerastes gasperettii*, (H) *Echis coloratus*.

thus the reserve's species list will need to be updated as these new taxa are formally described. Likewise, the *Mesalina guttulata* species complex (recorded during our survey as *Mesalina* lineage 4 following Sindaco et al. 2018) is also undergoing taxonomic revision.

The four species not previously recorded from the KARNR region are *Trapelus agnetae*, *Hemidactylus granosus*, *Mesalina saudiarabica*, and *Diplometopon zarudnyi*. The occurrence of *M. saudiarabica* was confirmed by DNA barcoding, with three samples of this species occurring in the Ad Dahna sand stretch of the reserve. The occurrence of this species was unexpected

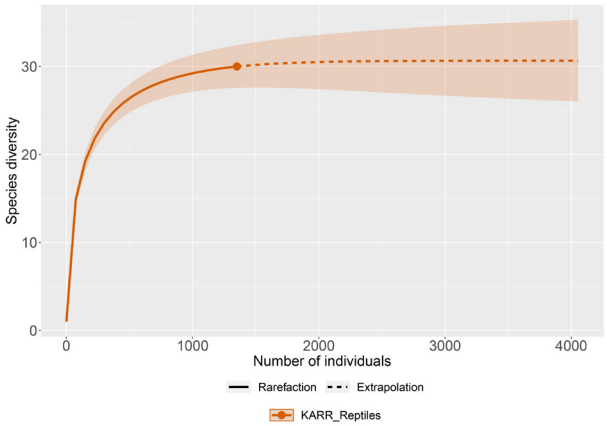

Fig. 10. Predictive species accumulation curve generated with the R package iNEXT. The solid line represents observations made during the 2022/23 survey period and the stippled line represents the extrapolation of the data to double the survey effort.

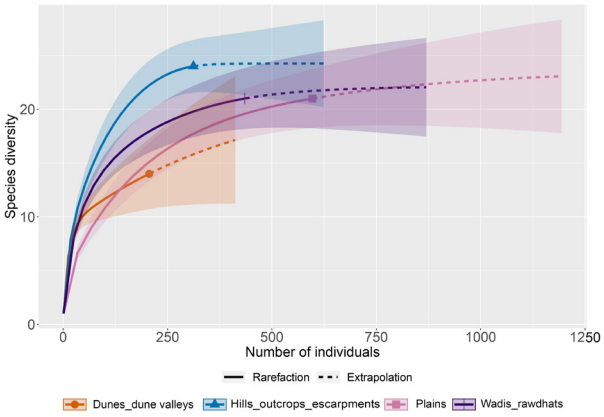

Fig. 11. Predictive species accumulation curves generated with the R package iNEXT for four different habitat types (Dunes and dune valleys; Hills, outcrops, and escarpments; Plains; and Wadis, rawhdats, and pans). The solid lines represent observations made during the surveys and the stippled lines represent the extrapolation of the data to double the survey effort.

based on its previously known distribution that was restricted to the western deserts of Saudi Arabia (Šmíd et al. 2017). Not only do these records represent a significant range extension of more than 600 km to the north-east from the previously known range, but they also indicate the need for more detailed taxonomic investigations and herpetofaunal surveys in this understudied region as well as in other parts of central Saudi Arabia that remain largely under-surveyed.

One of the most frequently detected species within the KARNR is *Uromastyx aegyptia*. This species is widespread throughout the reserve and occurs in all broad habitat types. *Uromastyx aegyptia* is listed as Vulnerable by the IUCN, with threats relating to increasing anthropogenic pressures such as agricultural expansion, overgrazing, and poaching (IUCN 2023). Since the reserve was established, proactive measures have been taken to prevent habitat degradation, and hunting of *U. aegyptia* within the reserve borders has been made illegal. This highlights the role of KARNR as an important conservation area for reptiles in general, but especially for this Threatened species. Climate change is thought to be an additional threat to *U. aegyptia*, with ecological niche modelling projections indicating that habitat suitability across the Arabian Peninsula will decrease by 2070 (Kechnebbou et al. 2021). Under the worst-case scenario, only extremely limited areas within the reserve are predicted to remain suitable for *U.*

Table 2. Summary of species diversity calculations performed using the species accumulation curves generated with the R package iNEXT. For the KARNR as a whole and each of the broadscale habitat types, the diversity indices (Species richness, Shannon, and Simpson) are summarized in terms observed and estimated diversity with the standard error and upper and lower confidence levels. The iNEXT completeness percentage was calculated based on the observed versus estimated diversity.

Assemblage	Diversity	Observed	Estimator	Standard error	LCL	UCL	iNEXT completeness
KARNR	Species richness	31.00	31.67	3.15	31.00	37.84	97.88
	Shannon diversity	8.39	8.48	0.29	7.92	9.04	98.94
	Simpson diversity	4.75	4.76	0.17	4.43	5.09	99.79
Dunes and dune valleys	Species richness	14.00	21.96	6.29	14.00	34.29	63.75
	Shannon diversity	8.17	8.60	0.59	7.45	9.75	94.99
	Simpson diversity	6.30	6.47	0.54	5.40	7.53	97.42
Hills, outcrops, and escarpments	Species richness	24.00	24.25	5.97	24.00	35.95	98.97
	Shannon diversity	9.68	10.07	0.65	8.80	11.34	96.11
	Simpson diversity	6.33	6.44	0.50	5.46	7.42	98.29
Plains	Species richness	21.00	23.66	7.34	21.00	38.05	88.75
	Shannon diversity	4.89	4.99	0.31	4.39	5.60	97.94
	Simpson diversity	3.39	3.40	0.14	3.13	3.68	99.60
Wadis, rawhdats, and pans	Species richness	21.00	22.12	4.35	21.00	30.65	94.93
	Shannon diversity	6.37	6.54	0.44	5.69	7.40	97.41
	Simpson diversity	3.37	3.39	0.25	2.90	3.88	99.45

aegyptia, while suitability remains across KARNR for the best-case scenario (Kechnebbou et al. 2021). As such, the KARNR is an important sanctuary for the long-term protection of this species. However, future conservation plans for the reserve should focus not only on mitigating the impacts of anthropogenic pressures, but also on developing a monitoring program to identify potential range reductions within the reserve borders in the context of climate change.

The other reptile of conservation concern found within the reserve is *Tropiocolotes wolfgangboehmei*, which is listed as Data Deficient by the IUCN and considered one of the world's most range-restricted reptiles (IUCN 2023; Meiri et al. 2018). This species was previously known from only three localities (Šmíd et al. 2021). We observed two individuals of this species during our survey, one at a previously known site within the 10 km buffer (300 m from the reserve boundary), while the other represents a new locality record (25 km north-east from the known site). Both records are from the Hills, outcrops, and escarpments habitat type. Future surveys in the KARNR should target this range-restricted species at additional sites and investigate its ecological requirements to assess the extent of its protection within the reserve.

In conclusion, our herpetological survey in the KARNR contributes significantly to our knowledge of the reptile diversity in east-central Saudi Arabia and provides a robust baseline for the region. The occurrences of 34 reptile species have been confirmed for the reserve, including four not previously recorded. The survey effort assessment, through predictive species accumulation curves and diversity indices, indicates that our methodology was adequate by documenting an estimated 97.89% of reptile species present in the KARNR. However, we acknowledge that further field and genetic investigations may reveal additional species.

The distribution of species richness across different broad habitat types reveals insights into the importance of habitat heterogeneity in supporting reptile diversity. The KARNR is a protected area of significant conservation importance, both at the regional and global scales. Its protection is beneficial for species of conservation concern such as *Uromastyx aegyptia* (VU) and *Tropiocolotes wolfgangboehmei* (DD), and for the more common and widespread reptile species and assemblages in the region. Ongoing taxonomic revisions and the potential impacts of climate change on sensitive species emphasize the need for more rigorous monitoring and for the implementation of adaptive conservation strategies. Our findings not only contribute significantly to the herpetofaunal knowledge of the Arabian Peninsula but also serve as a foundational resource for conservation planning and assessments, long-term monitoring, and regional comparative studies.

Acknowledgments.—We are grateful to the King Abdulaziz Royal Nature Reserve for commissioning this study and Namariq Engineering Services for their logistical support. All work was conducted under permit 23-43WP, issued by the Reserve Authority. A special thank you goes to Sayd Haj Aissa and Saaed Nezar Alam for their invaluable assistance in ensuring smooth logistics, local arrangements, and on-the-ground support during our survey. We extend our appreciation to Lukáš Pola, Doubravka Velenská, Denis Hlaváč, Marek Uvizl, and Vojtěch Waldhauser for their contributions to the lab work associated with DNA barcoding. JŠ acknowledges the support of the Czech Science Foundation (GAČR) under grant number 22-12757S. We also express our gratitude to Awatef Abiadh, Ben Orban, Caroline Vasicek Gaugris, Colleen Lindberg, Graeme Wolfaard, Lukas Niemand, Marco Alexandre, Nicole Burri, Petrus Rossouw, Retief Grobler, Rio Button, Saaed Nezar Alam, and Tobi van Loggerenberg for providing additional records while in the field. We thank the anonymous reviewers for their comments and suggestions.

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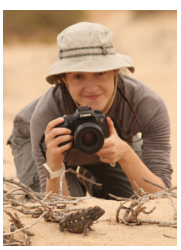

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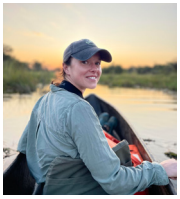

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