



Diversity and conservation of terrestrial, freshwater, and marine reptiles and amphibians in Saudi Arabia

¹Abdulhadi A. Aloufi, ²Zuhair S. Amr, ³Mohammad A. Abu Baker, and ⁴Nashat Hamidan

¹Department of Biology, Taibah University, Al-Madinah Al-Munawwarah, KINGDOM OF SAUDI ARABIA ²Department of Biology, Jordan University of Science and Technology, Irbid, JORDAN ³Department of Biology, The University of Jordan, Amman, JORDAN ⁴Royal Society for the Conservation of Nature, Amman, JORDAN

Abstract.—This review describes the diversity of the freshwater, marine, and terrestrial herpetofauna of the Kingdom of Saudi Arabia that consists of 128 extant species and subspecies; 121 species and subspecies of reptiles and seven species of amphibians according to current taxonomic systems. Four main categories of threats affecting amphibians and reptiles were identified as habitat loss and degradation, water issues, human disturbance and related activities, and legislation and public awareness; and supportive examples for each category are provided. Key species that require urgent protection are: *Chalcides levitoni*, *Platyceps insulanus*, *Dasypeltis scabra*, *Hemidactylus alfarraji*, *Hemidactylus asirensis*, *Hemidactylus mindiae*, *Lytorhynchus gasperetti*, *Pelomedusa barbata*, *Phoenicolacerta kulzeri* ssp., *Tropicolotes wolfgangboehmei*, and *Varanus yemenensis*, due to their limited distribution, as well as *Uromastix aegyptia* due to over-harvesting and trade. According to the IUCN Red List, eight of these species are Data Deficient, four are Vulnerable, one Critically Endangered, and one Near Threatened. The status of herpetofauna in Saudi Arabia is still far from being completely understood. Nevertheless, the lack of formal conservation measures and low public concern makes amphibians and reptiles extremely vulnerable in the near future.

Keywords. Anura, endemic, Sauria, Squamata, Testudines, threats

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Introduction

Over the past century, several major publications on the herpetofauna of Saudi Arabia have appeared (Schmidt 1941; Haas 1957; Haas and Werner 1969; Al-Wailly and Al-Uthman 1971; Farag and Banaja 1980; Hillenius and Gasperetti 1984; Balletto et al. 1985; Arnold 1986; Al-Sadoon 1988, 1989; Gasperetti 1988; Al-Sadoon et al. 1991; Leviton et al. 1992; Gasperetti et al. 1993; Schätti and Gasperetti 1994; Al-Johany 1995). Many additional publications have provided distributional data, taxonomic reviews, descriptions of new species, and new records (Hussein and Darwish 2001; Wilms and Böhme 2007; Al-Sadoon 2010; Cunningham 2010; Al-Shammari 2012; Šmid et al. 2013, 2016; Al-Johany et al. 2014; Aloufi and Amr 2015; Alshammari and Ibrahim 2015; Al-Sadoon et al. 2016; Alshammari et al. 2017; Alqahtani 2018; Sindaco et al. 2018).

Some of these papers presented erroneous records that should be interpreted with caution. For example, Schätti and Gasperetti (1994) suggested that records of *Tarentola*

muritanica [sic] and *Tarentola annularis* by Farag and Banaja (1980) should be referred to as *Hemidactylus flaviviridis*. Also, the record of *Mabuya quinquetaeniata* from date gardens north of Umluj by Farag and Banaja (1980) certainly refers to *Trachylepis brevicollis*. Dekinesh (1991) included records of *Mabuya vittata*, *Stenodactylus petrii*, *Trapelus savignyi*, and *Sphenops sepsoides* from Faid Hema, which later proved to be misidentifications. Some of the contributions of Masood (2012) and Masood and Asiry (2012) to the herpetofauna of the Asir region comprise obvious misidentifications and erroneous records that call for amendments. For example, Masood and Asiry (2012) reported *T. annularis*, *T. mauritanica*, *Tropicolotes tripolitanus*, and *Trachylepis vittata* from the Asir region. Considering the known distribution ranges of the aforementioned species (e.g., see Schleich et al. 1996), these *Tarentola* records must be doubted as well. Other doubtful records include those of *Stenodactylus sthenodactylus*, *Trapelus pallidus*, and *Trapelus mutabilis* (Masood and Asiry 2012).

The conservation status of the terrestrial reptiles

Correspondence. ¹aaroufi@taibahu.edu.sa, ²amrz@just.edu.jo, ³Ma.Abubaker@ju.edu.jo, ⁴nashat@rscn.org.jo

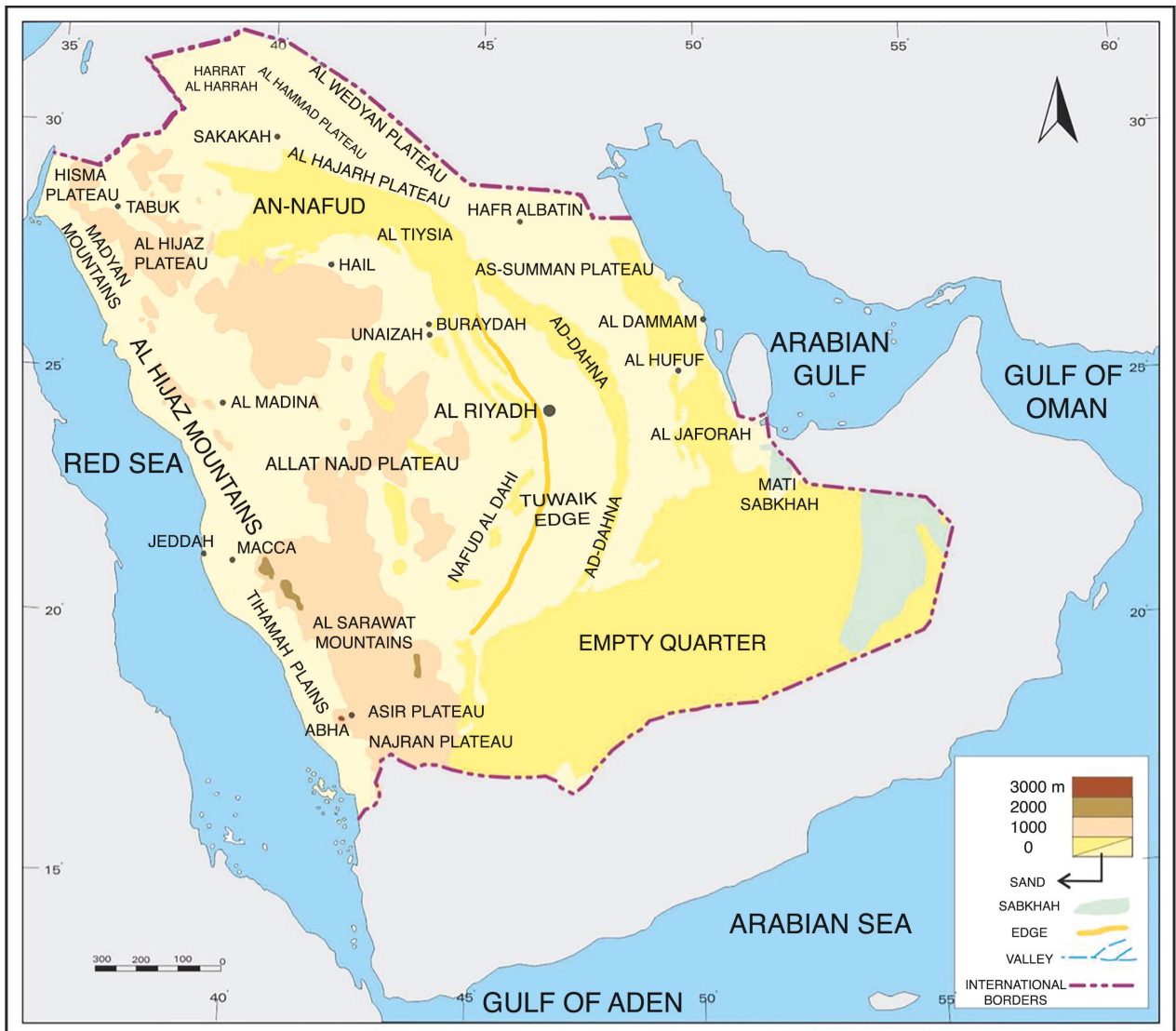


Fig. 1. Map of Saudi Arabia showing main geographic landmarks (after Al-Nafie 2018).

of the Arabian Peninsula was assessed by Cox et al. (2012). Some more recent works have focused on individual countries. Carranza et al. (2018) discussed the diversity, distribution, and conservation of the reptiles of Oman, including records for 101 species of terrestrial reptiles. The distribution of reptiles in Qatar was presented by Cogălniceanu et al. (2014). Gardner (2013) compiled distribution data for the amphibians and reptiles of Oman and the United Arab Emirates. Disi et al. (2014) gave a comprehensive account of the diversity, conservation, and major threats for the herpetofauna of Jordan.

Since the publications of Arnold (1986) on the lizards of Arabia, Gasperetti (1988) on the snakes of Arabia, and Leviton et al. (1992) on herpetofauna of the Middle East, no updated lists covering Saudi Arabia have been published. Many reptilian and amphibian species have been subjected to critical reviews on the molecular and morphological levels which resulted in the adoption of new names. In addition to documenting and updating the herpetofauna, based on current taxonomic understanding,

it is important to examine the impacts of continuous drastic changes in habitats and some practices in Saudi Arabia, as the reptiles and amphibians are being subjected to several forms of threats that have caused declines in some species.

In this study, the diversity, conservation status, and major threats affecting the herpetofauna of Saudi Arabia are identified, and an updated list, including the up-to-date taxonomic names, is provided.

Materials and Methods

The Approach

Scientific names of the reptilian species mostly follow Uetz et al. (2018). The taxonomic treatment of the genus *Phrynocephalus* by Melnikov et al. (2014) was adopted. The systematic position of *Trapelus ruderatus* (formerly *Trapelus persicus*) was followed after Ananjeva et al. (2013). For amphibians, the genera listed in the Amphibian Species of the World (<http://research.amnh>).



Fig. 2. Ad Disah mountains, southwest Tabuk. *Photo by S. Al Jathli.*

org/vz/herpetology/amphibia/) were adopted. The conservation status for species follow Cox et al. (2012). Data on the threats affecting the reptiles and amphibians were compiled from field observations mainly made by the first author, A. Aloufi. Distributional limits and localities were checked according to Sindaco and Jeremčenko (2008) for lizards, and Sindaco et al. (2013) for snakes.

Geographical Setting

Saudi Arabia is a vast country occupying 2,026,213 km² with diverse habitats that range from extreme arid and basalt deserts, to mountain ranges and highlands, sand and sandstone deserts, marine and freshwater ecosystems, and numerous wadi systems and oases (Figs. 1–3). Below is a general description of the geography of the Kingdom of Saudi Arabia, including the Coastal Plains, the Western Highlands, various plateaus, and sand dunes.

A. Coastal Plains

In Saudi Arabia, two strips of coastal plains extend along the Red Sea and the Arabian Gulf.

The coastal plain of the Red Sea (Tihammah Plains) lies between the Red Sea coast to the west and the western highlands to the east. It is a narrow transitional area between the Red Sea shelf and the high shelf mountains, which becomes wider in the south; reaching up to 40 km wide near Jazan. To the north, it becomes narrower until it disappears near 26°N latitude, south of Al Wajah. With the exception of some parts near the northern tip of the Red Sea, it is characterized by an abundance of capes. The northern half of the plain is characterized by a multitude of marine crusts, forming small marine

clefts that deepen inland by water flow descending from the coastal mountains such as Rabigh and Yanba'. The southern half is characterized by the spread of salt flats (*Sabkha*), especially along the coast, in addition to some sandy settlements near the coast, and the spread of some small black lava areas.

The coastal plain of the Arabian Gulf is limited to the gulf coast to the east, and the As-Summan plateau to the west. It is a flat plain largely covered by sand and salt flats (*Sabkha*), especially near the coast and along its side. This plain is devoid of wadi systems, with numerous sea extensions and capes. The lowest point in Saudi Arabia (24 m asl) lies within its southern part, near Al Homor Sabkha.

B. Western Highlands

The western highlands consist of a mountain chain that extends along the coast of the Gulf of Aqaba and the Red Sea, stretching from Jordan to the north and reaching the Republic of Yemen to the south. These mountains are a refractive ladder-shaped formation, and its western slopes descend precipitously towards the Red Sea, while inland they descend gradually eastward. The altitude increases towards the south, reaching as high as 3,015 m asl at the mountain of Al-Sūda, northwest of Abha. The western highlands are divided into three main mountain series: Al Sarawat mountains in the south, Al Hijaz mountains in the middle, and Madyan mountains in the north (Fig. 2).

C. Plateaus

The hills or plateaus located to the east of the western highlands cover large areas, and they generally descend to the east and north-east.

1. Western Plateaus

Najran and Asir plateaus are located to the east of the Sarawat mountains (Figs. 3A–B), between the Kingdom's borders and the Republic of Yemen to the south, and the drainage system of Wadi Al-Dawasir valley to the north. In this area of overlap they form a transitional area between the Sarawat Mountains in the west and the Empty Quarter in the east. Their altitudes range between 900 and 1,700 m asl.

The Hijaz Plateau is located to the east of the Hijaz Mountains, and is bounded by the Hijaz mountain to the west, the Najd Plateau to the east, the plateaus of Najran and Asir to the south, and the Hisma Plateau to the north. Its southern part descends to the north and west, and its northern part descends to the east and north-east. The altitude reaches up to 1,200 m asl. Some of its stretches include the black lava desert of Khaybar.

Hisam Plateau is located to the north-west of the Kingdom, to the east of the mountains of Medyan, and to the west and north-west of Tabuk. It is confined between the border with Jordan to the north, and Hijaz Plateau to the south. It descends eastwards, and ranges from 800–1,700 m asl. Black lava deserts cover some of its southern parts (Fig. 2).

2. Central Plateaus

The Central Plateau is represented by An-Nafud or Najd plateau, a large plateau located east of the Hijaz Plateau. It is bordered to the west by Hijaz Plateau, to the east by the sands of Ad-Dahna, to the south by the Wadi al-Dawasir, and by the Greater An-Nafud to the north. The An-Nafud near Tayma lies within the Arabian shield and is called Najd High Plateau, while the eastern part, known as Lower Najd Plateau, lies within the Arabian shelf. It gradually descends towards the north-east in the north, to the east in the middle section, and to the south-east in the south, with an average altitude of 500–1,000 m asl. The high plateau is characterized by igneous and metamorphic rocks. In contrast, the lower Najd Plateau is characterized by sand and rocky edges that extend from the north near Zulfi to the center of the southwestern extremities of the Empty Quarter, with a length of about 1,200 km.

3. Eastern Plateaus

The Eastern Plateaus are located in the eastern part of the Kingdom, and the extent from its center to its north-eastern edges is all within the Arabian shelf. The Eastern Plateaus include four main plateaus.

As-Summan Plateau is located to the east of Najd Plateau, where it is separated from Najd by Nofud Al Dahna, and extends from the north to the south. It is inserted between Ad-Dahna in the west, the coastal plains of the Arabian Gulf in the east, and from Yibreen to the

south of Wadi al-Sahba in the south. This plateau is wide and semi-flat, descending slightly towards the north-east and east, with altitudes ranging from 50–400 m asl.

Al Hajarh Plateau is located north-east of the Kingdom, between As-Summan Plateau in the south and Al-Hammad Plateau in the north. It is confined between the course of Wadi Al-Batin in the south, the Valley of Aba Al-Qor in the north, between the Nafud Al Dahna and the Greater Dahna in the west, and the border of the Kingdom of Saudi Arabia with Iraq in the east. A section of Al Hajarh also extends north of the Greater An-Nafud towards the west, reaching Al-Jawf, and it then descends towards the east and north-east, with altitudes ranging from 400–600 m asl.

Al Hammad Plateau is located in the north-east of the Kingdom, and it is confined between the Al Hajarh plateau in the south, the borders of the Kingdom with Iraq in the north, and between Harrat Al Harrah in the west (Fig. 3C), and Al Wedyan Plateau in the east. It descends to the northeast with altitudes ranging from 750–850 m asl.

Al Wedyan Plateau is located in the far northeast of the country, bordering Al Hammad plateau in the east, and it is considered as an extension of Al Hammad Plateau, descending towards the north-east, with altitudes ranging from 500–750 m asl. It is crossed by several wadi systems that descend the Al Hammad plateau and drain rainwater to Iraq during the rainy season.

D. Sand Dunes

The sand dunes cover a large proportion of the Kingdom's area, about 677,715 km², or about 33.8% of its total area. The sands of the Empty Quarter, Greater Nafud (Fig. 3E–F), and Al Jaforah are the largest sandy seas, together representing about 90% of the sand dunes in the country. The sand dunes are concentrated in the eastern part of the Kingdom, while small sandy gatherings occur in the Arabian shield to the west, in addition to small and scattered dunes along the Red Sea coast, formed from the presence of sediment sources, watercourses, and wind.

Biogeographical regions of Saudi Arabia

Al-Nafie (2008) defined four main phytogeographical regions in the Kingdom of Saudi Arabia (Fig. 4). The Saharo-Arabian region occupies the greatest part of Saudi Arabia, extending from the north, through central Arabia. It includes As-Summan, Al Hammad, Al Hajarh, Al Wedyan, and Najd plateaus, An-Nafud, Ad-Dahna, and the Empty Quarter sand dunes. The Afromontane region has mountains higher than 1,800 m asl, is dominated by *Juniperus procera* and other evergreen shrubs, and covers a narrow strip extending along Asir and Sarawat mountains. The Sudanian region stretches over a narrow

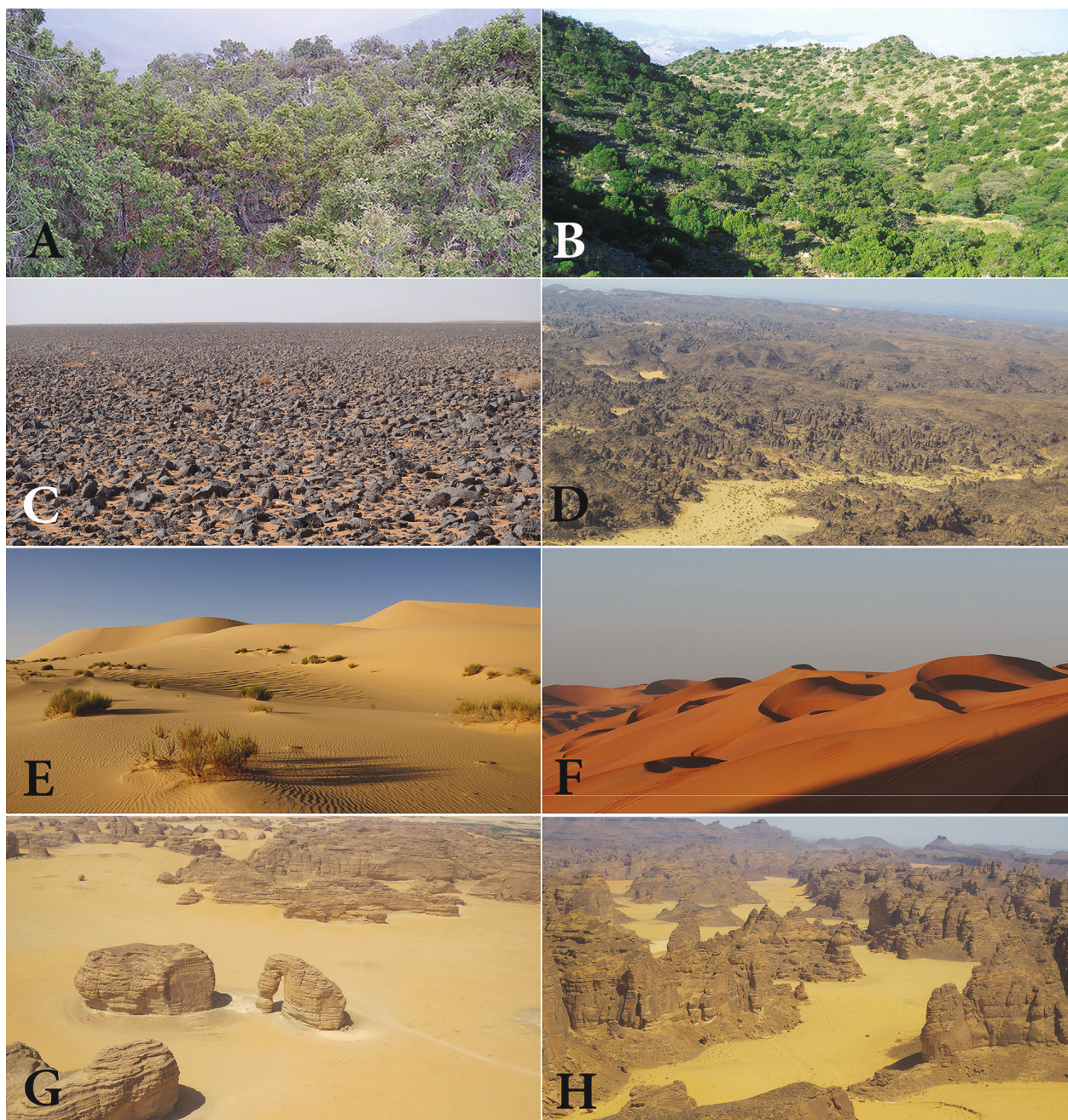


Fig. 3. Landscapes and habitats in Saudi Arabia. (A) *Juniperus procera* forests in Raydah reserve. (B) *Juniperus procera* forests in Asir mountains. (C) Harrat Al Harrah. (D) Harat Ewardh. (E) Sand dunes in the Greater Nofoud. (F) Sand dunes in the Empty Quarter. (G) Elephant mountain in Al-Ula. (H) Sharaan sand stones mountains in Al-Ula. Photos by K. Al Shamari (A), O. Llewellyn (B), and A. Aloufi (C–H).

strip along the Red Sea coast as well as the Arabian Gulf coast. Finally, the Sudanian-Zambian region surrounds the Afromontane region, with overlaps with the Sudanian region along the southwestern portions.

Results

Amphibians

Balletto et al. (1985) gave the most comprehensive treatment to date of the amphibians of Arabia. Additional distribution data were presented for central (Al-Johany

2014) and southwestern Saudi Arabia (Al-Qahtani and Al-Johany 2018), by Schätti and Gasperetti (1994) for southwest Arabia, and by Alshammari and Ibrahim (2018) for Hai'l. Recent studies replaced *Hyla savignyi* with the newly described taxon *Hyla felixarabica* (Gvožik et al. 2010). Previous records of *Bufo viridis* are now considered as *Bufo boulengeri* (see <http://research.amnh.org/vz/herpetology/amphibia/>). In total, seven species belonging to four families (Bufonidae, Ranidae, Hylidae, and Dicroglossidae) are known from the Kingdom of Saudi Arabia (Fig. 5, Table 1).

Diversity and conservation of reptiles and amphibians in Saudi Arabia

Table 1. List of amphibians and reptiles of Saudi Arabia, their IUCN conservation status, and levels of threats. IUCN status: Critically Endangered (CR); Data Deficient (DD); Endangered (EN); Least Concern (LC); Near Threatened (NT); Not Evaluated (NE); Vulnerable (VU). Threats: 1 = Deforestation, 2 = Destruction of the natural vegetation in the desert, 3 = Agricultural expansion, 4 = Overgrazing, 5 = Water extraction and climate change, 6 = Pollution and marine debris, 7 = Recreational activities and tourism, 8 = Direct persecution, 9 = Trade and commercial collection, 10 = Hunting and poaching. Levels of threats: L = Low, M = Medium, H = High.

	IUCN status		Threats									
	Global	Regional	1	2	3	4	5	6	7	8	9	10
Amphibia												
Family Bufonidae												
<i>Bufo boulengeri</i> (Lataste, 1879)	LC	NE					L				L	
<i>Duttaphrynus dhufarensis</i> (Parker, 1931)	LC	NE					M				L	
<i>Sclerophrys arabica</i> (Heyden, 1827)	LC	NE					M				L	
<i>Sclerophrys tihamica</i> (Balletto and Cherchi, 1973)	LC	NE					M				L	
Family Ranidae												
<i>Pelophylax ridibundus</i> (Pallas, 1771)	LC	NE					M				L	
Family Hylidae												
<i>Hyla felixarabica</i> Gvoždik et al. 2010	NE	NE					M				L	
Family Dicroglossidae												
<i>Euphlyctis ehrenbergii</i> (Peters, 1863)	LC	NE					M				L	
Reptilia												
Family Geoemydidae												
<i>Mauremys caspica</i> (Gmelin, 1774)	LC	VU					H				L	
Family Pelomedusidae												
<i>Pelomedusa barbata</i> Petzold et al. 2014	NE	NE	M				H				L	
Family Cheloniidae												
<i>Eretmochelys imbricata</i> (Linnaeus, 1766)	CR	NE					L				L	
<i>Chelonia mydas</i> (Linnaeus, 1758)	EN	NE					H				L	
<i>Caretta caretta</i> (Linnaeus, 1758)	VU	NE					L				L	
<i>Lepidochelys olivacea</i> (Eschscholtz, 1829)	VU	NE					L				L	
Family Dermochelyidae												
<i>Dermochelys coriacea</i> (Vandelli, 1761)	VU	NE					L				L	
Family Chamaeleonidae												
<i>Chamaeleo calypttratus calcarifer</i> Peters 1871	LC	LC	M								L	
<i>Chamaeleo chamaeleon orientalis</i> Parker 1938	LC	LC		L							L	
Family Agamidae												
<i>Acanthocercus adramitanus</i> (Anderson, 1896)	LC	LC	L						L			
<i>Acanthocercus yemenensis</i> (Klausewitz, 1954)	LC	LC	L						L			
<i>Phrynocephalus arabicus</i> Anderson, 1984	LC	LC			L				L			
<i>Phrynocephalus nejdensis</i> Haas, 1957	LC	LC			L				L			
<i>Phrynocephalus macropeltis</i> Melnikov et al. 2014	NE	NE			L				L			
<i>Phrynocephalus maculatus</i> Anderson, 1872	NE	NE			L				L			
<i>Pseudotrapelus sinaitus</i> Heyden, 1827	LC	LC				L			L			
<i>Pseudotrapelus aqabensis</i> Melnikov et al. 2012	NE	NE				L			L			
<i>Stellagama stellio</i> (Linnaeus, 1758)	LC	LC				L			L			
<i>Trapelus agnetae</i> (Werner, 1929)	LC	LC			L				L			
<i>Trapelus flavimaculatus</i> Rüppell, 1835	LC	LC			L				L			
<i>Trapelus jayakari</i> (Anderson, 1896)	DD	DD		L	L	L			L			
<i>Trapelus persicus</i> (Blanford, 1804)	LC	LC		L		L			L			

Table 1 (continued). List of amphibians and reptiles of Saudi Arabia, their IUCN conservation status, and levels of threats. IUCN status: Critically Endangered (CR); Data Deficient (DD); Endangered (EN); Least Concern (LC); Near Threatened (NT); Not Evaluated (NE); Vulnerable (VU). Threats: 1 = Deforestation, 2 = Destruction of the natural vegetation in the desert, 3 = Agricultural expansion, 4 = Overgrazing, 5 = Water extraction and climate change, 6 = Pollution and marine debris, 7 = Recreational activities and tourism, 8 = Direct persecution, 9 = Trade and commercial collection, 10 = Hunting and poaching. Levels of threats: L = Low, M = Medium, H = High.

	IUCN status		Threats									
	Global	Regional	1	2	3	4	5	6	7	8	9	10
<i>Uromastyx aegyptia</i> (Forsk., 1775)	VU	VU		H		H			L		H	H
<i>Uromastyx ornata</i> Heyden, 1827	LC	LC		L		L			L			
Family Gekkonidae												
<i>Bunopus tuberculatus</i> Blanford, 1874	LC	LC			L							
<i>Cyrtopodion scabrum</i> (Heyden, 1827)	LC	LC				L			L	L		
<i>Hemidactylus alfarraji</i> Šmíd et al. 2016	NE	NE				L			L	L		
<i>Hemidactylus asirensis</i> Šmíd et al. 2016	NE	NE				L			L	L		
<i>Hemidactylus flaviviridis</i> Rüppell, 1835	LC	LC				L			L	L		
<i>Hemidactylus granosus</i> Heyden, 1827	NE	NE				L			L	L		
<i>Hemidactylus mendiae</i> Baha El Din, 2005	NE	NE				L			L	L		
<i>Hemidactylus montanus</i> Busais and Joger, 2011						L			L	L		
<i>Hemidactylus persicus</i> Anderson, 1872	LC	LC				L			L	L		
<i>Hemidactylus robustus</i> Heyden, 1827						L			L	L		
<i>Pseudoceramodactylus khobarensis</i> Haas, 1957	LC	LC		L	L				L	L		
<i>Stenodactylus doriae</i> (Blanford, 1874)	LC	LC		L	L				L	L		
<i>Stenodactylus grandiceps</i> Haas, 1952	LC	LC		L	L				L	L		
<i>Stenodactylus slevini</i> Haas, 1957	LC	LC		L	L				L	L		
<i>Stenodactylus yemenensis</i> Arnold, 1980	LC	LC		L	L				L	L		
<i>Trigonodactylus arabicus</i> (Haas, 1957)	LC	LC		L		L			L	L		
<i>Tropicolotes nattereri</i> Steindachner, 1901	LC	LC		L		L			L	L		
<i>Tropicolotes wolfgangboehmei</i> Wilms et al. 2010	DD	DD		L	L					L		
Family Phyllodactylidae												
<i>Ptyodactylus hasselquistii</i> (Donndorff, 1798)	LC	LC				L				L		
Family Sphaerodactylidae												
<i>Pristurus carteri</i> (Gray, 1863)	LC	LC				L			L	L		
<i>Pristurus flavipunctatus</i> Rüppell, 1835	LC	LC				L			L	L		
<i>Pristurus minimus</i> Arnold, 1977	LC	LC				L			L	L		
<i>Pristurus popovi</i> Arnold, 1982	LC	LC				L			L	L		
<i>Pristurus rupestris</i> Blanford, 1874	LC	LC				L			L	L		
Family Lacertidae												
<i>Acanthodactylus boskianus</i> (Daudin, 1802)	LC	LC		L	L	L			L			
<i>Acanthodactylus gongrorhynchatus</i> Leviton and Anderson, 1967	DD	DD		L	L				L			
<i>Acanthodactylus grandis</i> Boulenger, 1909	LC	LC		L	L	L			L			
<i>Acanthodactylus haasi</i> Leviton and Anderson, 1967	LC	LC		L	L	L			L			
<i>Acanthodactylus opheodurus</i> Arnold, 1980	LC	LC		L	L	L			L			
<i>Acanthodactylus robustus</i> (Werner, 1929)	LC	LC		L	L	L			L			
<i>Acanthodactylus schmidti</i> Haas, 1957	LC	LC		L	L	L			L			
<i>Acanthodactylus scutellatus</i> (Audouin, 1827)	LC	LC		L	L	L			L			
<i>Acanthodactylus orientalis</i> Angel, 1936	LC	LC		L	L	L			L			
<i>Acanthodactylus tilburyi</i> Arnold, 1986	LC	LC		L	L	L			L			

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Table 1 (continued). List of amphibians and reptiles of Saudi Arabia, their IUCN conservation status, and levels of threats. IUCN status: Critically Endangered (CR); Data Deficient (DD); Endangered (EN); Least Concern (LC); Near Threatened (NT); Not Evaluated (NE); Vulnerable (VU). Threats: 1 = Deforestation, 2 = Destruction of the natural vegetation in the desert, 3 = Agricultural expansion, 4 = Overgrazing, 5 = Water extraction and climate change, 6 = Pollution and marine debris, 7 = Recreational activities and tourism, 8 = Direct persecution, 9 = Trade and commercial collection, 10 = Hunting and poaching. Levels of threats: L = Low, M = Medium, H = High.

	IUCN status		Threats									
	Global	Regional	1	2	3	4	5	6	7	8	9	10
<i>Mesalina arnoldi</i> Sindaco et al., 2018	NE	NE							L			
<i>Mesalina adramitana</i> (Boulenger, 1917)	LC	LC		L	L				L			
<i>Mesalina bernoullii</i> (Schenkel, 1901)	NE	NE		L	L				L			
<i>Mesalina brevirostris</i> Blanford, 1874	LC	LC		L	L				L			
<i>Mesalina guttulata</i> (Lichtenstein, 1823)	LC	LC		L	L				L			
<i>Mesalina olivieri</i> (Audouin, 1829)	LC	LC		L	L				L			
<i>Mesalina saudiarabica</i> Moravec et al. 2017	NE	NE		L	L				L			
<i>Ophisops elbaensis</i> Schmidt and Marx, 1957	DD	DD		L	L				L			
<i>Philochortus neumanni</i> Matschie, 1893	LC	LC		L	L				L			
<i>Phoenicolacerta kulzeri</i> ssp.	EN	NE			L	L			L			
Family Scincidae												
<i>Ablepharus pannonicus</i> (Fitzinger, 1824)	LC	LC		L		L						
<i>Chalcides levitoni</i> Pasteur, 1978	DD	DD	L	L	L	L						
<i>Chalcides ocellatus</i> (Forskål, 1775)	LC	LC		L		L						
<i>Eumeces schneideri</i> (Daudin, 1802)	LC	LC		L		L						
<i>Eurylepis taeniolatus</i> Blyth, 1854	LC	LC			L							
<i>Scincus hemprichii</i> Wiegmann, 1837	LC	LC		L	L				L			
<i>Scincus mitranus</i> Anderson, 1871	LC	LC		L	L				L			
<i>Scincus scincus</i> (Linnaeus, 1758)	LC	LC		L	L				L			
<i>Trachylepis brevicollis</i> (Wiegmann, 1837)	LC	LC		L		L			L			
<i>Trachylepis septemtaeniatus</i> (Reuss, 1834)	LC	LC		L		L			L			
Family Trogonophidae												
<i>Diplometopon zarudnyi</i> Nikolsky, 1907	LC	LC		L	L	L						
Family Varanidae												
<i>Varanus griseus</i> (Daudin, 1803)	LC	LC		L	L				L		M	
<i>Varanus yemenensis</i> Böhme et al. 1989	DD	DD		L	L				L		L	
Family Atractaspididae												
<i>Atractaspis andersonii</i> Boulenger, 1905	LC	LC								M		
<i>Atractaspis engaddensis</i> Haas, 1950	LC	LC								M		
Family Boidae												
<i>Eryx jaculus</i> Linnaeus, 1758	LC	LC		L	L				L		L	
<i>Eryx jayakari</i> Boulenger, 1888	LC	LC		L	L				L		L	
Family Colubridae												
<i>Dasypeltis scabra</i> (Linnaeus, 1758)	LC	LC	L			L						
<i>Eirenis coronella coronella</i> (Schlegel, 1837)	LC	LC		L	L							
<i>Eirenis coronella fennelli</i> Arnold, 1982	LC	LC		L	L							
<i>Lytorhynchus diadema</i> (Duméril et al. 1854)	LC	LC		L	L							
<i>Lytorhynchus gasperetti</i> Leviton, 1977	DD	DD			L	L						
<i>Platyceps elagantissimus</i> (Günther, 1878)	LC	LC		L		L						
<i>Platyceps insulanus</i> (Mertens, 1965)	DD	DD		L	L	L						
<i>Platyceps rhodarchis</i> (Jan, 1865)	LC	LC		L		L					L	

Table 1 (continued). List of amphibians and reptiles of Saudi Arabia, their IUCN conservation status, and levels of threats. IUCN status: Critically Endangered (CR); Data Deficient (DD); Endangered (EN); Least Concern (LC); Near Threatened (NT); Not Evaluated (NE); Vulnerable (VU). Threats: 1 = Deforestation, 2 = Destruction of the natural vegetation in the desert, 3 = Agricultural expansion, 4 = Overgrazing, 5 = Water extraction and climate change, 6 = Pollution and marine debris, 7 = Recreational activities and tourism, 8 = Direct persecution, 9 = Trade and commercial collection, 10 = Hunting and poaching. Levels of threats: L = Low, M = Medium, H = High.

	IUCN status		Threats									
	Global	Regional	1	2	3	4	5	6	7	8	9	10
<i>Platyceps saharicus</i> Schätti and McCarthy, 2004	LC	LC		L		L						
<i>Platyceps variabilis</i> (Boulenger, 1905)	LC	LC		L		L						
<i>Platyceps ventromaculatus</i> (Gray, 1834)	LC	LC		L		L						
<i>Spalerosophis diadema cliffordii</i> (Schlegel, 1837)	LC	LC		L		L					L	
<i>Telescopus dhara</i> (Forsskål, 1775)	LC	LC		L	L	L						
Family Elapidae												
<i>Hydrophis curtus</i> (Shaw, 1802)	LC	NE						L				
<i>Hydrophis cyanocinctus</i> Daudin, 1803	LC	NE						L				
<i>Hydrophis lamberti</i> Smith, 1917	LC	NE						L				
<i>Hydrophis lapemoides</i> (Gray, 1849)	LC	NE						L				
<i>Hydrophis gracilis</i> (Shaw, 1802)	LC	NE						L				
<i>Hydrophis platurus</i> (Linnaeus, 1766)	LC	NE						L				
<i>Hydrophis schistosa</i> Daudin, 1803	LC	NE						L				
<i>Hydrophis spiralis</i> (Shaw, 1802)	LC	NE						L				
<i>Hydrophis viperinus</i> (Schmidt 1852)	LC	NE						L				
<i>Naja arabica</i> Scortecci, 1932	LC	LC							L	H	M	
<i>Walterinnesia aegyptia</i> Lataste, 1887	LC	LC								L		
<i>Walterinnesia morgani</i> (Mocquard, 1905)	VU	VU								L		
Family Leptotyphlopidae												
<i>Myriopholis macrorhyncha</i> (Jan, 1860)	LC	LC		L								
<i>Myriopholis nursii</i> (Anderson, 1896)	LC	LC		L								
Family Typhlopidae												
<i>Indotyphlops braminus</i> (Daudin, 1803)	LC	LC		L								
Family Psammophiidae												
<i>Psammophis schokari</i> (Forsskål, 1775)	LC	LC		L							M	
<i>Rhagerhis moilensis</i> (Reuss, 1834)	LC	LC		L						M		
Family Viperidae												
<i>Bitis arietans</i> Merrem, 1820	LC	LC								L	L	
<i>Cerastes cerastes</i> (Linnaeus, 1758)	LC	LC								L	L	
<i>Cerastes gasperetti</i> Leviton and Anderson, 1967	LC	LC								L	L	
<i>Echis borkini</i> Cherlin, 1990	LC	LC	L							L		
<i>Echis coloratus</i> Günther, 1878	LC	LC								L	L	
<i>Pseudocerastes fieldi</i> Schmidt, 1930	LC	LC								L		

Reptiles

Twenty-one families in two orders, Testudines (Cheloniidae, Dermochelyidae, Geoemydidae, and Pelomedusidae) and Squamata (Agamidae, Atractaspididae, Boidae, Chamaeleonidae, Colubridae, Gekkonidae, Elapidae, Lacertidae, Leptotyphlopidae, Phyllodactylidae, Psammophiidae, Scincidae, Sphaerodactylidae, Trogonophidae, Typhlopidae, Varanidae, and Viperidae), including 55 genera and 121

species, have been recorded from Saudi Arabia (Table 1).

Testudines

Two species of freshwater turtles belonging to two families have been recorded from Saudi Arabia: *Pelomedusa barbata* (Pelomedusidae, Petzold et al. 2014) and *Mauremys caspica* (Geoemydidae, Gasperetti et al. 1993; Vamberger et al. 2013). Alqahtani (2017) published a detailed account on the status and distribution



Fig. 4. Phytogeographical regions of Saudi Arabia (after Al-Nafie 2008).

of *P. subrufa* (= *Pelomedusa barbata*) in Saudi Arabia.

Five species of marine turtles in two families (Cheloniidae and Dermochelyidae) are known to occur in the Red Sea (Ross 1985; Gasperetti et al. 1993; Al-Merghani et al. 2000; Pilcher et al. 2014; Mancini et al. 2015). The Green Turtle, *Chelonia mydas*, and the Hawksbill Turtle, *Eretmochelys imbricata*, are considered as the most common species in the Red Sea (Fig. 6), where they feed and nest (PERSGA 2004).

Squamata

Family Chamaeleonidae

Hillenius and Gasperetti (1984) listed two taxa of chameleons in Saudi Arabia: *Chamaeleo calypratus calcarifer* Peters 1871 and *Chamaeleo chamaeleon orientalis* Parker 1938. Both species are confined to the coastal mountains of the Red Sea, reaching up to 2,500 m asl.

Family Agamidae (Fig. 7)

Fifteen species belonging to six genera (*Acanthocercus*, *Phrynocephalus*, *Pseudotrapelus*, *Stellagama*, *Trapelus*, and *Uromastix*) have been reported from Saudi Arabia.

The status of species of the genus *Phrynocephalus* were subjected to revisions based on the morphological and genetic differences. Melnikov et al. (2014) differentiated between the members of the *Phrynocephalus arabicus* Anderson, 1984 complex. Their study revealed that *Ph. arabicus sensu stricto* is distributed in southern Arabia (Yemen, Oman, southern Saudi Arabia), and *Ph. nejdensis* in north-western Arabia (southern Jordan, northern and central Saudi Arabia), while *Ph. macropeltis* is known in the eastern coastal Arabia (eastern Saudi Arabia, United Arab Emirates).

Rastegar-Pouyani (2000) published a controversial opinion on the identity of *Trapelus persicus*. He stated that the specific name “*runderatus*” (Olivier, 1804) antedates “*persicus*” (Blandford 1804), so the new taxonomic combination is *Trapelus runderatus runderatus* (Olivier, 1804) (= the former *T. p. persicus*), and the western subspecies *T. p. fieldi* has a new taxonomic combination. Therefore, the name “*persicus*” is no longer available and comes under the synonymy of “*runderatus*.” More recently, Ananjeva et al. (2013) clarified the systematic position of *Trapelus runderatus* in relation to *T. persicus*, and for constancy and stability of the taxonomy of this group, the International Code of Zoological Nomenclature ruled that these two species are separate. In addition, *Pseudotrapelus aqabensis* was

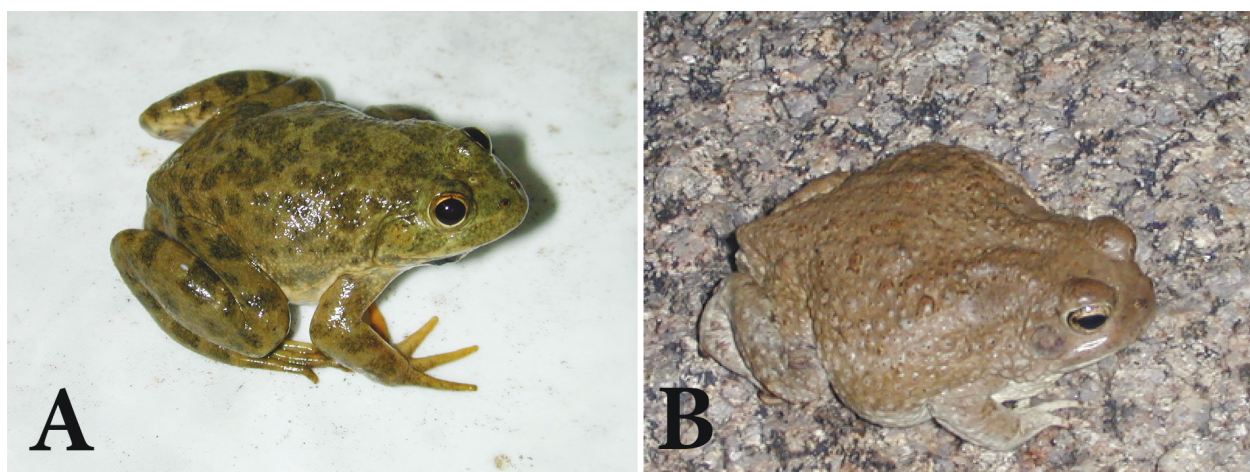


Fig. 5. Amphibians of Saudi Arabia. (A) *Euphyctis ehrenbergii*. (B) *Sclerophrys tihamica*. Photos by T. Papenfuss.

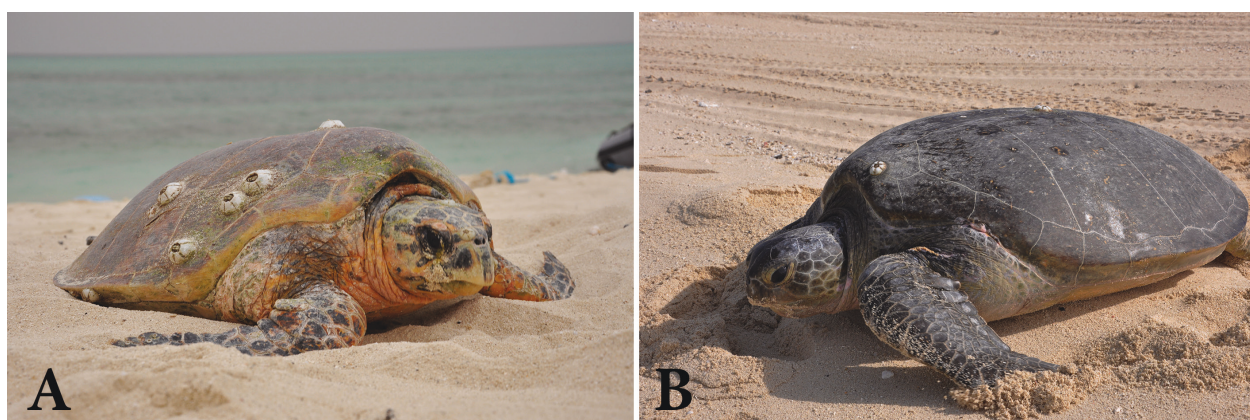


Fig. 6. Marine turtles of Saudi Arabia. (A) *Eretmochelys imbricata*. (B) *Chelonia mydas*. Photos by A. Al Mansi.

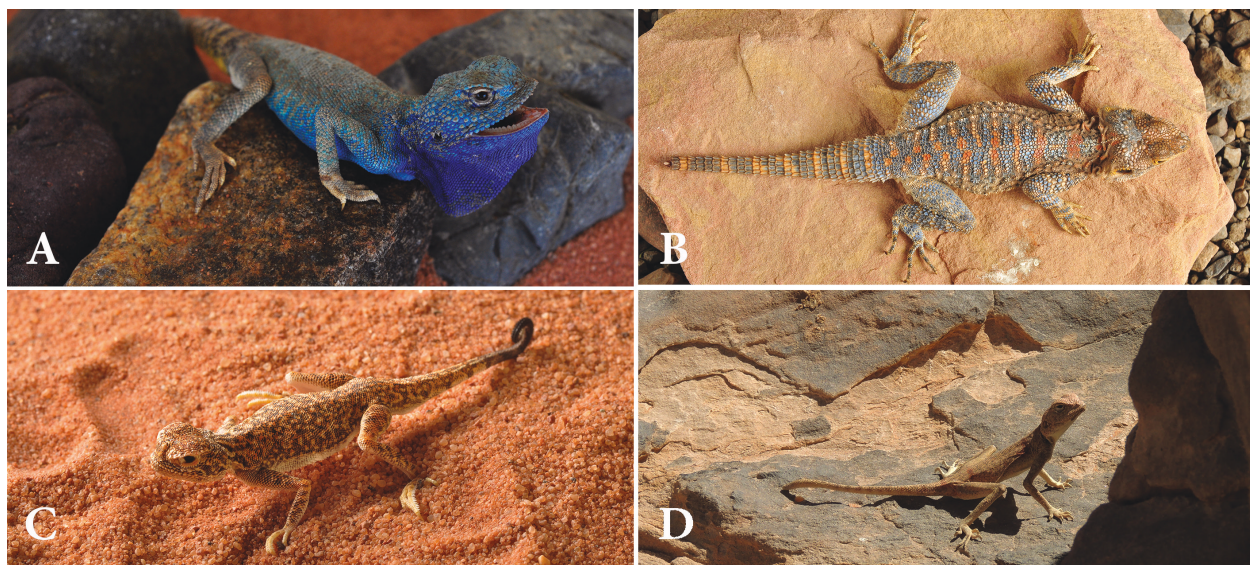


Fig. 7. Agamids of Saudi Arabia. (A) *Trapelus flavimaculatus*. (B) *Stellagama stellio*. (C) *Phrynocephalus nejdensis*. (D) *Pseudotrapelus sinaitus*. Photos by A. Aloufi.

added recently to the herpetofauna of Saudi Arabia by Aloufi and Amr (2015) and Tamar et al. (2016b).

Family Gekkonidae

This family is represented by seven genera (*Bunopus*,

Cyrtopodion, *Hemidactylus*, *Pseudoceramodactylus*, *Stenodactylus*, *Trigonodactylus*, and *Tropicolotes*), including 18 species. The genus *Stenodactylus* was revised by Arnold (1980), Metallinou et al. (2012), and Nazarov et al. (2018), and it now includes four species. Šmíd et al. (2013) revised the genus *Hemidactylus*. They considered

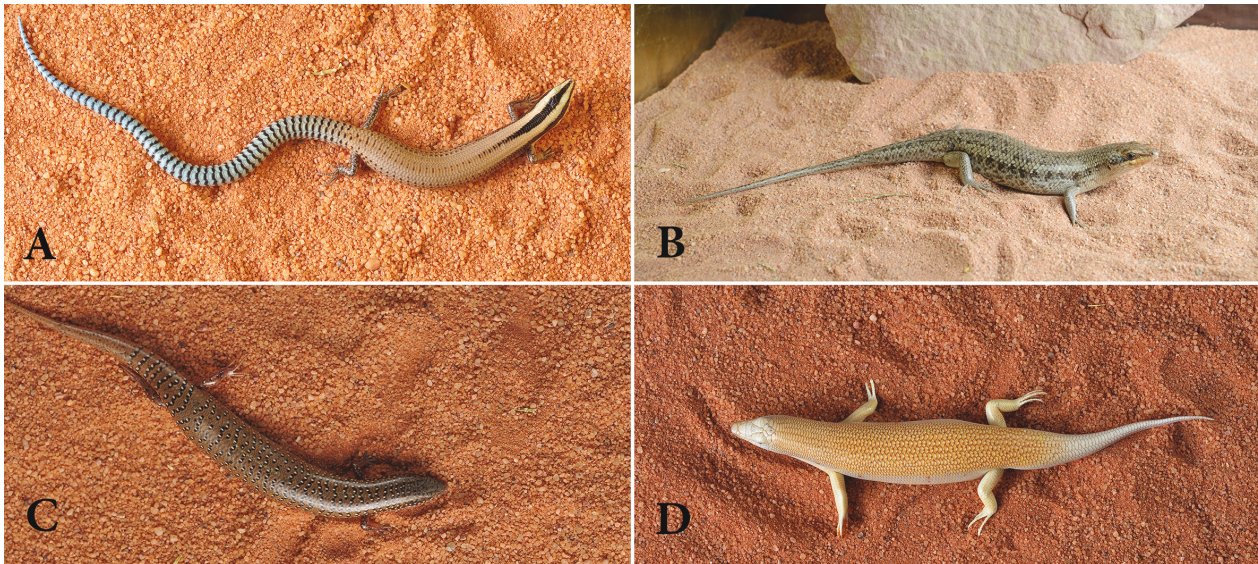


Fig. 8. Scincids of Saudi Arabia. (A) *Eurylepis taeniolatus*. (B) *Trachylepis brevicollis*. (C) *Chalcides ocellatus* (D) *Scincus scincus*. Photos by A. Aloufi.

all previous records of *Hemidactylus turcicus* from Saudi Arabia as *Hemidactylus granosus*. Recently Šmíd et al. (2016) described two endemic species for Saudi Arabia: *Hemidactylus alfarraji* from Najran area and *Hemidactylus asirensis* from Asir Province. *Hemidactylus mindiae* is a new addition to the geckos of Saudi Arabia (Aloufi and Amr 2015). Therefore, the number of *Hemidactylus* species known from Saudi Arabia is now eight. One record of *Hemidactylus sinaitus* Boulenger, 1885 from Seir Farasan Kebir should be considered with care (see Sindaco et al. 2014). *Tropicolotes wolfgangboehmei* is known from a single locality in central Saudi Arabia (Wilms et al. 2010).

Family Phyllodactylidae

This family is represented by one genus and one species, *Ptyodactylus hasselquistii*. Recent molecular studies revealed that the genus *Ptyodactylus* in the Arabian Peninsula consists of two species complexes for *P. hasselquistii*, as eastern and western clades (Metallinou et al. 2015). A new species, *Ptyodactylus ananjevae*, was described from Al Mudawwarah, southern Jordan, very close to Tabuk Province, so it is most likely to also occur in Saudi Arabia (Nazarov et al. 2013).

Family Sphaerodactylidae

The Semaphore geckos of Saudi Arabia are represented by five species. Their taxonomic status was discussed by Arnold (2009). Recently, the status of *Pristurus rupestris* was evaluated on a molecular basis, which showed that *P. rupestris* is restricted to eastern Oman, while a western clade, *Pristurus* sp. 1, is distributed from central coastal Oman, through Yemen, Saudi Arabia, and north to southern Jordan (Badiane et al. 2014). The northwestern population in Saudi Arabia may be assigned as *Pristurus*

guweirensis, however, we still prefer to continue referring to *Pristurus* sp. 1 as *Pristurus rupestris* until further studies validate their separation.

Family Scincidae (Fig. 8)

Ten species of skinks have been reported from Saudi Arabia, and they are represented by six genera (*Ablepharus*, *Chalcides*, *Eumeces*, *Eurylepis*, *Scincus*, and *Trachylepis*). The three species of the genus *Scincus* are strictly sand-dwelling species. *Chalcides levitoni* is known from only one locality in southwestern Saudi Arabia (Pasteur 1978). *Panaspis wahlbergi* was erroneously reported from Saudi Arabia by Al-Jumaily (1984).

Family Lacertidae

Twenty species of lacertids occur in Saudi Arabia. They belong to five genera (*Acanthodactylus*, *Mesalina*, *Ophisops*, *Philochortus*, and *Phoenicolacerta*). Species of the genus *Acanthodactylus* were extensively studied at the molecular level (Tamar et al. 2016a), and constitute the highest number of species, followed by species of the genus *Mesalina*. *Acanthodactylus tilburyi* is known only from Saudi Arabia and southern Jordan (Sindaco and Jeremčenko 2008). Among lizards of the genus *Mesalina*, Sindaco et al. (2018) described *Mesalina arnoldi* from southwestern Saudi Arabia and Yemen, and *Mesalina saudiarabica* was described from Mahazat as-Sayd, near Makkah (Šmíd et al. 2017). By now, *Mesalina brevirostris* is known to be distributed in eastern Saudi Arabia, while *Mesalina bernoullii* is known from north-eastern Saudi Arabia (Šmíd et al. 2017). Al-Sadoon et al. (2016) recorded *Acanthodactylus orientalis* and *Acanthodactylus robustus* for the first time from Turaif region. *Phoenicolacerta kulzeri* ssp. was recently recorded from Al Konah, Tabuk (Aloufi and Amr 2015).

Family Trogonophidae (Fig. 9)

This family is represented by a single species in Saudi Arabia. The Zarudny Worm Lizard, *Diplometopon zarudnyi*, was reported from several localities mostly in eastern Saudi Arabia.

Family Varanidae

Two species of the family Varanidae were reported to occur in Saudi Arabia. *Varanus griseus* is widely distributed across Saudi Arabia, while *Varanus yemenensis* is confined to extreme southwestern Saudi Arabia.



Fig. 9. The Zarudny Worm Lizard, *Diplometopon zarudnyi*. Photos by A. Aloufi.

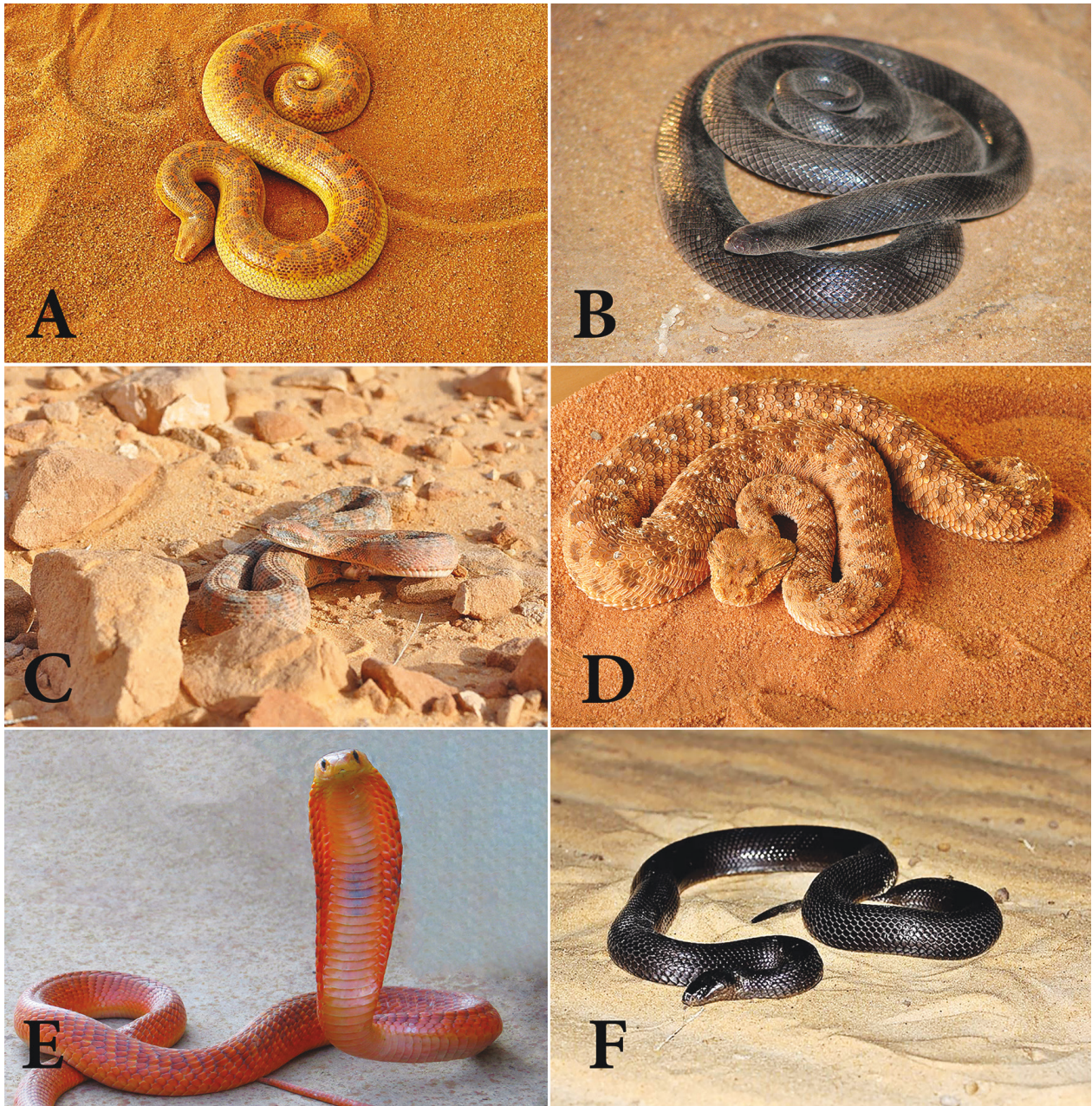


Fig. 10. Snakes of Saudi Arabia. (A) *Eryx jayakari*. (B) *Atractaspis engaddensis*. (C) *Echis coloratus*. (D) *Cerastes cerastes*. (E) *Naja arabica*. (F) *Walterinnesia aegyptia*. Photos by A. Al Salman (A–B, F), M. Al Sulimi (C), A. Aloufi (D), and M. Al Mesheni (E).

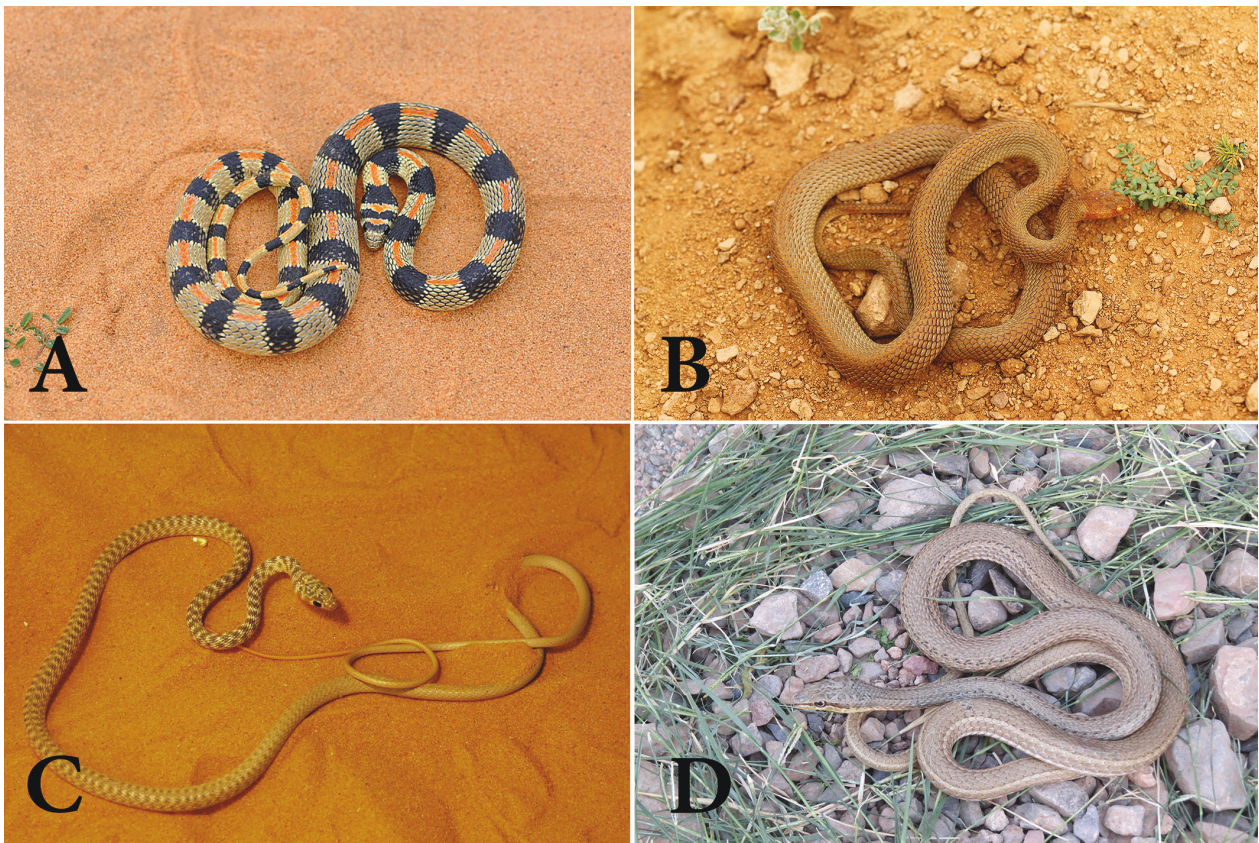


Fig. 11. Snakes of Saudi Arabia. **(A)** *Platyceps elegantissimus*. **(B)** *Telescopus dhara*. **(C)** *Platyceps rhodarchis*. **(D)** *Psammophis schokari*. Photos by M. Al Sulimi (A), A. Al Salman (B–C), and A. Aloufi (D).

Family Leptotyphlopidae

Two species of the genus *Myriopholis*, *Myriopholis macrorhyncha* and *Myriopholis nursii*, have been reported from Saudi Arabia (Egan 2007).

Family Typhlopidae

This family is represented by a single species, *Indotyphlops braminus*. This Asian species is widespread and has become almost cosmopolitan in distribution. It is believed to have been introduced into Arabia through imported plant pots (Egan 2007).

Family Atractaspididae (Fig. 10B)

Mole vipers in Saudi Arabia are exemplified by two species: *Atractaspis andersonii* distributed in southwestern Saudi Arabia, and *Atractaspis engaddensis* in the northwestern and central parts of the country.

Family Boidae (Fig. 10A)

This family is represented by two species. *Eryx jaculus* is known from eastern Saudi Arabia, while *Eryx jayakari* is more common and widespread throughout the country.

Family Colubridae (Fig. 11)

This family includes 13 species and subspecies in six genera (*Dasypeltis*, *Eirenis*, *Lytorhynchus*, *Platyceps*, *Spalerosophis*, and *Telescopus*). Three species are confined to the extreme southwest of Saudi Arabia (*Platyceps insulanus*, *Dasypeltis scabra*, and *Lytorhynchus gasperetti*). *Eirenis coronella coronella* is known from eastern Saudi Arabia, while *Eirenis coronella fennelli* is known from the western part of the country. Schätti and McCarthy (2004) confirmed the occurrence of *Platyceps saharicus* in the Arabian Peninsula. We came across a photographed specimen of *Rhynchochalamus melanocephalus* from Al Konah, near Tabuk and another one from Jabal Al Ward west of Al-Ula (data not shown). However, the validity of its occurrence in Saudi Arabia requires further specimens.

Family Psammophiidae (Fig. 11D)

This family includes two species in two genera (*Psammophis* and *Rhagerhis*). Both species are desert adapted species with wide ranging distributions across the Kingdom (Gasperetti 1988).

Family Elapidae (Fig. 10E and F)

Three species of terrestrial elapids belonging to two genera (*Naja* and *Walterinnesia*) are known in Saudi

Arabia. Nilson and Rastegar-Pouyani (2007) considered the eastern population of *Walterinnesia* as *Walterinnesia morgani* and the western population as *Walterinnesia aegyptia*. *Naja arabica* is distributed to the west of the country.

Nine species of marine snakes belonging to the genus *Hydrophis* have been reported from the waters of the Arabian Gulf. The nomenclature of sea snakes in Table 1 follow Rezaie-Atagholipour et al. (2016).

Family Viperidae (Fig. 10C and D)

Six species in four genera (*Bitis*, *Cerastes*, *Echis*, and *Pseudocerastes*) of vipers are known in Saudi Arabia. *Bitis arietans*, *Cerastes cerastes*, and *Echis borkini*, are confined to the southwest, while *Pseudocerastes fieldi* occurs to the extreme north on the border with Jordan within Harat Al Harah. *Cerastes gasperetti* is the most common viper, especially in sandy areas.

Relict species

Pelomedusa barbata represents a relict population and is known from southwestern Saudi Arabia (Gasperetti et al. 1993). This African species may have either migrated to southern Arabia or originated in Arabia (Gasperetti et al. 1993; Vargas-Ramírez et al. 2016). The Caspian Turtle, *Mauremys caspica*, reaches the most southeastern range of its distribution around Al Qatif, Al Hufhuf, and Al Uqayr (Gasperetti et al. 1993; Fritz et al. 2008), and these populations are considered as relicts. The population of *Phoenicolacerta kulzeri* ssp. from Al Konah, in the northwest of Saudi Arabia, represents a relict in the sandstone formation of Hisma (Aloufi and Amr 2015).

Endemic species

Seven species are strictly endemic to the Kingdom of Saudi Arabia. *Tropicolotes wolfgangboehmei* is known from one locality in the proximity of Ath-Thumamah, central Saudi Arabia (Wilms et al. 2010). *Chalcides levitoni* was recorded only from Khasawijah, near Jizan (Pasteur 1978). Two snakes, *Platyceps insulanus*, known only from Sarso Island, Farasan Archipelago (Mertens 1965; Masseti 2014), and *Lytorhynchus gasperetti*, known from two localities in southwestern Saudi Arabia (Leviton 1977), are considered as endemic species. Recently, *Hemidactylus alfarraji* and *Hemidactylus asirensis* were described from southwestern Saudi Arabia (Šmíd et al. 2016), and *Mesalina saudiarabica* was described from Mahazat as-Sayd (Šmíd et al. 2017).

Other species can be considered as endemic at the level of the Arabian Peninsula. Four amphibians (*Duttaphrynus dhufarensis*, *Euphlyctis ehrenbergii*, *Sclerophrys arabica*, and *Sclerophrys tihamica*) are confined to the Arabian Peninsula. *Euphlyctis ehrenbergii* is distributed in southwest Saudi Arabia, and the Riyadh locality

may represent a release or escaped specimens from King Saud University Campus (Al-Johany et al. 2014). Among the reptiles, 20 species are restricted to the Arabian Peninsula excluding Socotra: *Acanthocercus adramitanus*, *Acanthocercus yemenensis*, *Acanthodactylus gongrorhynchatus*, *Acanthodactylus haasi*, *Atractaspis andersonii*, *Chamaeleo calytratus calcarifer*, *Echis borkini*, *Mesalina arnoldi*, *Mesalina adramitana*, *Naja arabica*, *Platyceps variabilis*, *Pristurus carteri*, *Pristurus minimus*, *Pristurus popovi*, *Scincus hemprichii*, *Stenodactylus arabicus*, *Stenodactylus yemenensis*, *Trapelus flavimaculatus*, *Trapelus jayakari*, and *Varanus yemenensis*.

According to the distribution maps given by Sindaco and Jeremčenko (2008), 50 out of 97 lizard species reported from the Arabian Peninsula are considered as endemic to the Peninsula. Twenty-five species of these reptile species are confined to the Arabian Hotspots Areas as outlined by Mallon (2011).

Discussion

The Conservation Status of the Reptiles and Amphibians of Saudi Arabia

Cox et al. (2012) revised the conservation status of the reptiles of the Arabian Peninsula, excluding the marine snakes and turtles. Among them, 101 species are listed as Least Concern, eight are Data Deficient, four are Vulnerable, one is Critically Endangered, and one is Near Threatened (Table 1). However, some species listed as Least Concern, such as *Echis borkini*, *Bitis arietans*, and *Naja arabica*, are under threats due to human practices and their status assessments require revision. Other species that are listed under Data Deficient, such as *Acanthodactylus gongrorhynchatus*, *Chalcides levitoni*, *Lytorhynchus gasperetti*, *Ophisops elbaensis*, *Platyceps insulanus*, *Tropicolotes wolfgangboehmei*, and *Varanus yemenensis*, have very restricted and very narrow ranges of distribution and so they should be assigned with conservation priorities.

Threats Affecting the Herpetofauna in Saudi Arabia

Four main categories of threats affect the amphibians and reptiles of Saudi Arabia. Some of these threats are very critical for a particular species, while other species may be impacted by more than one type of threat that may lead to population decline.

1. Habitat Loss and Degradation

The human population in Saudi Arabia has increased more than seven-fold in the last 50 years, now reaching up to about 33 million. This rapid growth resulted in the expansion of cities and urban centers at the expense of basic natural resources, especially wildlife and their habitats.

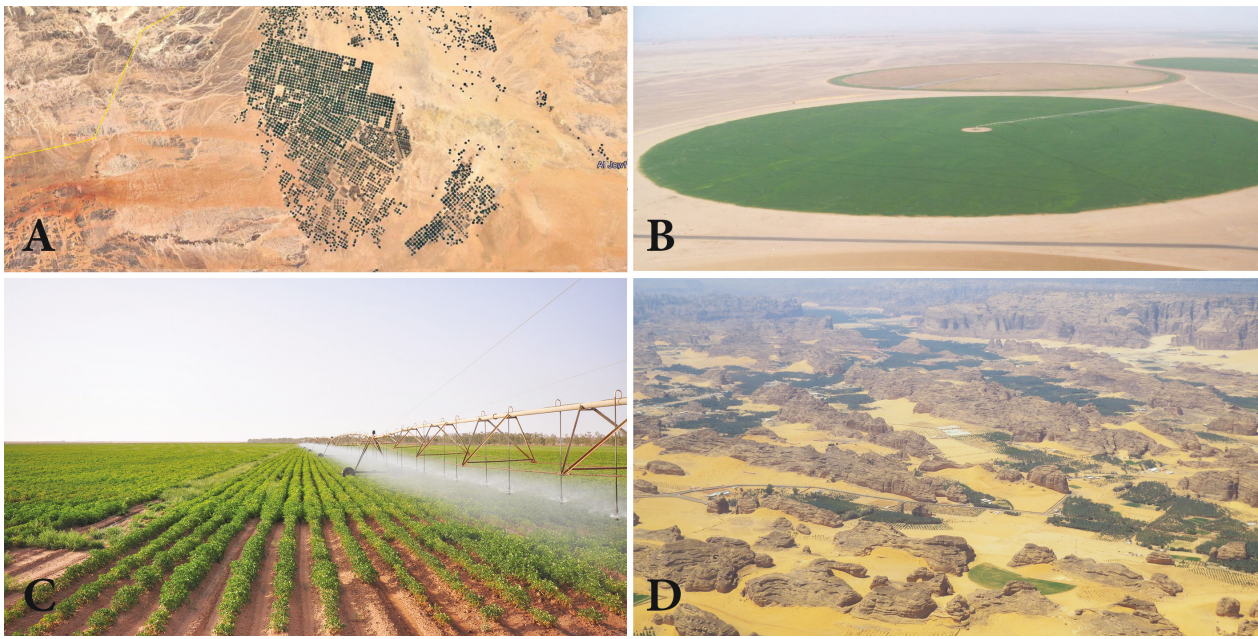


Fig. 12. Habitat disturbance due to farming. (A) Fodder farms at Al Jawf. (B) Fodder farm in Tabuk. (C) Vegetable farms in Tabuk area. (D) Farmland in Al-^Ula. Photos by A. Al Rabdi (B–C), and A. Aloufi (D).

Deforestation. It is estimated that forests and woodland cover about 27,000 km² of Saudi Arabia. These woodlands are mostly scattered along the Sarawat mountain in the southwestern region and are dominated by *Juniperus procera*. They have been subjected to misuse through exhaustive wood cutting and overgrazing activities, as well as uncontrolled forest fire and urbanization (El-Juhany 2009). Dieback of *J. procera* forests in the Raydah reserve of southwestern Saudi Arabia was attributed to climate change and the scarcity of rainfall, in addition to extensive farming projects around the area (Fisher 1997).

The southwestern mountains are the home of some rare, endemic, and perhaps endangered species such as *Acanthocercus adramitanus*, *Acanthocercus yemenensis*, *Chalcides levitoni*, *Chamaeleo calypttratus calcarifer*, *Euphlyctis ehrenbergii*, *Lytorhynchus gasperetti*, and *P. barbata*. The conservation status of these species should be assessed in relation to the current state of vegetation cover.

Destruction of the natural vegetation in the desert.

As a result of agricultural expansion in the sand deserts and wadi beds, the clearing of natural vegetation such as *Acacia raddiana*, *Acacia tortilis*, *Moringa peregrine*, *Nitraria retusa*, *Ziziphus spina-christi*, *Retama reaetam*, and *Haloxyton persicum*, and other chenopods has occurred. This clearance had direct effects on the lizards that either use these plants for shading or feed on them. Some species, such as *Trapelus persicus*, take refuge among *Nitraria retusa* shrubs. *Uromastyx aegyptia* is an herbivorous lizard that feeds on a variety of desert plants such as *Pennisetum divisum* and *Stipagrostis plumose*, while *Haloxyton salicornicum*, *Polygala erioptera*,

and *Aerva javanica* are consumed to a lesser extent (Cunningham 2000).

Agricultural expansion. Over the past 30 years, large parts of the deserts of Saudi Arabia were dedicated to agricultural projects for the production of wheat, and were converted recently for the production of green fodder and other crops (Fig. 12). Most of these projects are located around Tabuk, Tubarjal, Al Jawf, Hail, Buraydah, Sarj, Al Ula, and Wadi Al Dwasir, and were established since the early 1980s. It is estimated that an area of 694,549 ha was cultivated with fodder, wheat, and other crops in 2013. These projects were established in sandy areas and around wadi courses, due to the availability of groundwater. Alshammari and Ibrahim (2015) found that the smallest numbers of reptiles were collected from cultivated areas in Faid Hema, Ha'il region.

Much destruction of the natural habitats of sand-dwelling species takes place due to the plowing and construction of secondary roads in the desert. The most heavily affected species include *Acanthodactylus schmidtii*, *Cerastes gasperetti*, *Diplometopon zarudnyi*, *Eryx jaculus*, *Lytorhynchus diadema*, *Phrynocephalus nejdensis*, *Scincus hemprichii*, *Scincus mitranus*, *Scincus scincus*, *Stenodactylus doriae*, *Varanus griseus*, and *Uromastyx aegyptia*.

Overgrazing. The nomadic lifestyle is still practiced in many parts of Saudi Arabia. Sheep, goats, and camels are among the domestic animals roaming the deserts and the mountains during spring for grazing. This affects reptiles in many ways, including direct disturbance, lowering the vegetation cover, and actually abolishing entire plant communities. Species such as *Trapelus persicus* are af-

fects by grazing and are displaced from their natural habitats due to the year-round camel grazing on *Nitraria retusa* shrubs.

2. Water Issues

Water extraction and climate change. Intensive farming in many parts of the Saudi deserts for the production of wheat and fodder over the past 30 years has caused drastic changes in the water table. This has led to a dramatic decrease in natural vegetation cover and drying of natural ponds in the desert. The annual rainfall has shown a significant decrease (47.8 mm per decade), with a relatively high inter-annual variability, while temperatures (maximum, mean, and minimum) have increased significantly at rates of 0.71, 0.60, and 0.48 °C, respectively (Almazroui et al. 2012). Eventually, the water re-charge of aquifers will be affected for years to come. According to Alqahtani (2017), *Pelomedusa barbata* is facing threats in southwestern Saudi Arabia as a result of rainfall scarcity in recent years. In Al Hasa region, the number of breeding sites of *Mauremys caspica* was reduced from 159 in the early 1970s to about 19 in 2009, due to destruction of natural springs and construction of cemented canals, along with agricultural expansion (Aloufi 2009).

Pollution and marine debris. Cement dust pollution has affected the Green Turtle, *Chelonia mydas*, in Ras Baridi, reducing hatchling emergence success to only 40% due to the formation of hard domes above the nests which prevent emergence and cause mortality (Pilcher 1999). As a result of urban sewage discharge in open waters of the Red Sea, algal bloom formations have been associated with fibropapillomatosis disease, which is considered deadly to sea turtles (PERSGA/GEF 2004). Marine pollution is also widely believed to affect other sea turtles and snakes.

3. Human Disturbance and Related Activities

Recreational activities and tourism. Camping and driving in the open areas are on the increase in Saudi Arabia. Large vehicles and desert dirt bikes are widely used for racing on the sand dunes. This will certainly affect many sand-dwelling lizard and snake species, and cause disturbance (Table 1). At the same time, many shrubs and plants are destroyed during vehicle movement across the terrain. Tourism causes disturbance to fragile sensitive ecosystems, especially in places where relict or endangered species exist.

Direct persecution. Reptiles in general, and snakes in particular, are widely disliked animals. Many photos can be found posted on social media which show snakes that have been killed. Among them are venomous species, *Atractaspis andersonii*, *Atractaspis engaddensis*, *Cerastes gasperetti*, *Echis coloratus*, *Naja arabica*, and

Walterinnesia aegyptia. However, non-venomous snakes, such as *Spalerosophis diadema cliffordii*, *Psammophis schokari*, and *Platyceps rhodarchis*, are also often killed instantly even when they are encountered in the wilderness. In Saudi Arabia, all forms of geckos are killed since it is widely believed that they transmit leprosy.

Trade and commercial collection. We observed five species of snakes that were traded in the animal markets in Jeddah, Tabuk, Taif, and Al Madinah Al Monawarh: *Eryx jaculus*, *Naja arabica*, *Psammophis schokari*, *Platyceps rhodorachis*, and *Spalerosophis diadema cliffordii*. These snakes were cramped in plastic bottles and directly exposed to the sun. Lizards that were traded in the animal markets included *Chamaeleo chamaeleon*, *Chamaeleo calyptratus*, *Scincus mitranus*, *Scincus scincus*, *Uromastix aegyptia*, *Uromastix ornatus*, *Varanus yemenensis*, and *Varanus griseus*.

The Hawksbill Turtle, *Eretmochelys imbricata*, is collected from the Red Sea and sold in animal markets in Tabuk (Aloufi and Eid 2014). A less common item of trade is the Western Caspian Turtle, *Mauremys caspica*, but it can also be found in animal markets and pet shops (Aloufi and Eid 2014) and sold in Riyadh and Al Hasa Province. The population density of *Pelomedusa barbata* is under stress and has decreased greatly over the last few years in southwestern Saudi Arabia. However, it is commonly taken from its freshwater habitats in the southwest for trade (Alqahtani 2017).

The Spiny-tailed Lizard is sold for its meat, while skinks (*Scincus mitranus* and *Scincus scincus*) are sold as dried preparations that are prescribed in folk medicine as aphrodisiacs. For animal exhibits and shows, snakes such as *Eryx jaculus*, *Naja arabica*, and *Psammophis schokari* are in demand. Most of these animals are simply disposed of after the shows, and it has been estimated that over 100 Arabian cobras were killed in one season. For teaching purposes, university students and high schools purchase various amphibians, desert monitors, and spiny-tailed lizards.

Hunting and pouching. The consumption of eggs and meat of marine turtles has been reported in Saudi Arabia (Miller 1989), however, this practice is not very common. However, the major problem of hunting and direct harvesting of the Egyptian Spiny-tailed Lizard, *Uromastix aegyptia*, is alarming. Thousands of these animals are captured for human consumption and trade. The locals relish both the meat and the eggs. Truckloads of dead and slaughtered *dabbs* are posted on the hunter internet sites as a sign of pride (Fig. 13). Gravid females are in high demand due to their eggs. We counted over 17 females killed in one hunting trip, and females typically lay 17–41 eggs in one clutch during May or June (Bouskila 1984). This excessive harvest will certainly affect the population of *U. aegyptia*, whereas large numbers of females are killed in the eggs that are not



Fig. 13. The Egyptian Spiny-tailed Lizard, *Uromastyx aegyptia*, is hunted and killed by the hundreds and sold either alive or for its meat and eggs.

allowed to hatch. Both vitellogenic and oviductal eggs were observed among the females that had been killed (Fig. 13).

4. Legislative and Public Awareness

Enforcement. Although all wild animals in Saudi Arabia are protected by law, enforcement is still far behind in protecting the animals, and particularly reptiles. In fact, the Spiny-tailed Lizard, *U. aegyptia*, is included among the animals that are allowed to be hunted, together with birds. The hunting season for the Spiny-tailed Lizard is open from the beginning of August to the end of September outside of the protected areas, with no bag limit. This ambiguity in the number of allowed animals has led to a massive scale of hunting and killing of this vulnerable species. Until recently, the concept of conserving diversity has remained obscure to many decision makers in Saudi Arabia. The broad spectrum of biological diversity in the country requires trained individuals to reveal its importance for the country with

respect to various aspects, including socio-economic, ecotourism, scenic, and ethical perspectives.

Public awareness. As stated earlier, reptiles are disliked by most of the locals, and surrounded by mystery and superstitions. The general public attitude towards reptiles is a mix of aversion and fear that stems from deep-rooted traditional culture. Therefore, public awareness remains one of the most important issues for introducing the importance of reptiles to the general public; and public awareness of the importance of conservation is a high priority issue. The role of non-governmental organizations is to introduce wildlife conservation to various sectors of the community, mainly children and youngsters, as well as to rally support from decision makers.

The environmental public awareness towards animals in the Kingdom of Saudi Arabia remains limited, and is almost totally lacking for reptiles. The availability of books for providing scientific information to the public or at the level of high school education remains very limited. The lack of understanding in the general public is clearly illustrated by social media being so full of videos

and images of animal persecution and overhunting; with expression of great pride in such actions.

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Abdulhadi A. Aloufi is an Assistant Professor of Ecology, Faculty of Science, Taibah University. Abdulhadi received his Ph.D. from King Saud University, Saudi Arabia, and his main interests are biodiversity and conservation. He has published about 20 articles and two books on the biodiversity of the North Western region of Saudi Arabia and seabirds in Tabuk. Abdulhadi has also written five books for children about animal welfare published by The International Fund for Animal Welfare (IFAW).



Zuhair Amr is a Professor of Zoology and Animal Ecology in the Department of Biology, Jordan University of Science and Technology, Jordan. Zuhair received his Ph.D. in Zoology from the University of Rhode Island, Kingston, Rhode Island, USA. He has published over 150 papers and 10 books on various aspects of the ecology and systematics of mammals and reptiles in Jordan, Lebanon, Syria, the Palestinian Territories, and Saudi Arabia. Zuhair serves as the scientific authority for CITES in Jordan.



Mohammad Abu Baker is an Assistant Professor of Vertebrate Biology at The University of Jordan. Mohammad received his Ph.D. in Biology from The University of Illinois, Chicago, where he studied habitat selection and coexistence of African small mammals. He seeks to understand local and regional factors that influence biodiversity and species distribution using several empirical tools such as mark-recapture, camera trapping, foraging at experimental food patches, wildlife tracking, and GIS. Thus far, Mohammad has over 40 publications on the ecology, behavior, and natural history of mammals and reptiles in Jordan, Qatar, South Africa, Egypt, and the USA. (Photo by Bruce Patterson).



Nashat Hamidan is the director of the Conservation and Monitoring Center at the Royal Society for the Conservation of Nature, Jordan. Nashat received his Ph.D. from the University of Bournemouth, United Kingdom. He has extensive experience in nature conservation and reserves, and he has served in projects in Jordan, Saudi Arabia, Oman, United Arab Emirates (UAE), and Qatar.