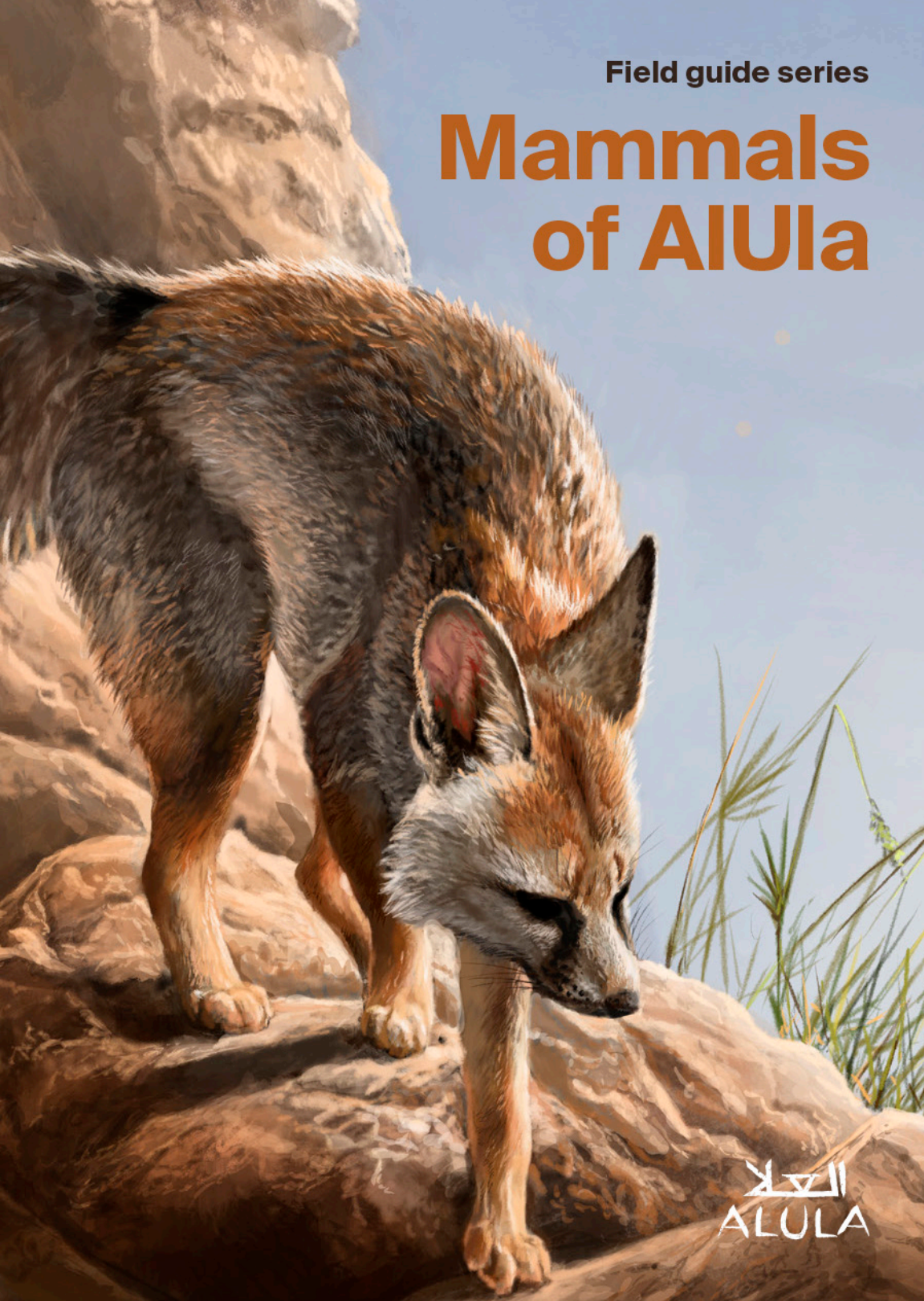
Field guide series

Mammals of AlUla



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First Edition
November 2024
ISBN
978-989-36005-5-9
Printed in KSA by
Sarawat Printing and Publishing
Citation
Bilancioni, M., Ferreira, D., Khalatbari, L., Boratyński, Z., Rebelo, H., Álvares, F., Liz, A.V., Alfakih, A., Taheri, A., Santos, B., Tarroso, P., and Brito, J.C. (2024). Mammals of AlUla. In: Gonçalves, D.V., Khalatbari, L., Santos, B., Yusefi, G.H., and Brito, J.C. (2024). Field guide series – Fauna of AlUla.

This book is a product of the collaborative efforts within the framework of the 'Inventory of AlUla Flora & Fauna' project. We extend our gratitude to every colleague from the Royal Commission for AlUla who contributed to the series. They include members of the Tourism Department for their support and the rangers who assisted in data collection.

WHERE SCIENCE IS ART

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Field guide series

Mammals of AlUla

Marcello Bilancioni, Diogo Ferreira, Leili Khalatbari, Zbyszek Boratyński, Hugo Rebelo, Francisco Álvares, André Vicente Liz, Ateah Alfakih, Bárbara Santos, Pedro Tarroso, José Carlos Brito

Royal Commission for AlUla
BIOPOLIS/CIBIO-InBIO/BIODESERTS

ARTE E CIÊNCIA

Contents

Foreword

As the Director of Research in the Wildlife & Natural Heritage Department of the Royal Commission for AlUla (RCU), it gives me great pleasure to introduce the Field Guide to the Mammals of AlUla. This book and its sister volumes are the culmination of 24 months of collaborative efforts by RCU and BIOPOLIS/CIBIO-InBIO, BIODESERTS research group. The guides are the result of the ambitious Inventory of AlUla Fauna project, which aimed to create a meticulous record of the biodiversity treasures of this extraordinary region.

This expertly curated book is a testament to the team's passion and curiosity towards the natural world and the deep-rooted desire to understand the underlying workings of nature. It is often the unexpected, the puzzling or the surprising that fire our imagination, inspire us to persevere every day in the field, and lead to new ideas and new discoveries. As such, there are few places left in the world for discovery – where there are empty pages in the book of biodiversity.

AlUla, Saudi Arabia, is one of those places.

The AlUla region, in the Kingdom of Saudi Arabia, stands as a testament to the rich tapestry of human history and natural wonders. Its landscape, framed by majestic sandstone mountains and remnants of extensive volcanic activity, has been a cradle for civilizations dating back millennia. The region has witnessed the rise and fall of ancient cultures such as the Dadanites, Lihyanites, and Nabataeans, leaving behind a legacy of architectural marvels and inscriptions that adorn its rugged cliffs.

As extensive as the cultural history is of AlUla, so was the biodiversity of the region underdescribed, until the 'Inventory of AlUla Fauna' project embarked on a journey to explore the biodiversity of this unique area. The dedicated team conducted surveys across 541 sites, employing various methodologies, resulting in an astounding assembly of over 31,000 observations, illuminating the fauna diversity of AlUla in unprecedented detail.

The findings of this endeavor are as remarkable as they are revelatory. A total of 622 taxa inhabiting the AlUla region were recorded. Out of those, 59% were never before reported, either for the AlUla region, for the Kingdom, or for science.

Consequently, a wide-ranging series of field identification guides on the region's mammals, birds, reptiles and invertebrates were compiled to share our discoveries with the world. The series of field guides will join already existing guides on the geology of AlUla and the historical uses of plants in the AlUla area. The intention in the publication of the various field guides is that they serve as invaluable resources for researchers, conservationists and nature enthusiasts alike.

RCU is committed to the conservation and sustainable management of the natural resources of AlUla County, in synergy with the preservation of the cultural and historical treasures, for generations to come.

We encourage you to visit AlUla and experience its natural beauty firsthand. During your adventure, may these field guides serve as your companions, enriching your understanding of the biodiversity that surrounds you.

Lourens van Essen
The Royal Commission for AlUla
Wildlife & Natural Heritage Department
Research & Advisory Director

1. Introduction

This guide presents the first in-depth evaluation of mammals in AlUla County and adjacent areas. It delivers fresh insights into the mammal diversity, distribution, and richness of the AlUla region. The guide features and describes 48 mammal species, including one non-native species (House Mouse) and one regionally extinct species (Cheetah). This number could potentially change in the future with new taxonomic studies, the discovery of cryptic species, and additional sightings (especially concerning bats and rodents). The content of this guide is derived from an extensive review of literature and over a year of dedicated field and laboratory research by the authors.

The guide's primary objective is to provide both novice and experienced mammalogists with the necessary tools for identifying mammal species in AlUla County. Located in the northwest of the Arabian Peninsula within Saudi Arabia, AlUla is part of the Palaearctic realm. The region mainly consists of Deserts & Xeric Shrublands and occupies a critical biogeographical position, intersecting five ecoregions and two global biodiversity hotspots. This strategic location is home to a wide range of flora and fauna, particularly those adapted to arid environments. The Arabian Peninsula hosts 166 known mammal species, of which 21 (13%) are endemic and six near-endemic (70% or more of their range covering that region). Across this region, species richness is highest in north-western areas. High diversity and endemism are also found in the mountain ranges of southwestern Saudi Arabia and western Yemen, the Hajar Mountains, and the marsh areas and northern mountains of Iraq. However, information about mammal diversity and distribution in Saudi Arabia and AlUla is still scarce. Therefore, the Royal Commission for AlUla (RCU) initiated the creation of a mammal inventory for the region.

AlUla stands as a unique example of the coexistence between human history and natural heritage. It is quickly becoming a world-renowned destination for travellers looking for extraordinary experiences and breathtaking desert scenery. It also exemplifies global initiatives that aim to unify natural and cultural heritage as part of a living environment. Aligned with Vision 2030, RCU's development program includes diverse

projects in archaeology, tourism, culture, education, and the arts. Key elements of this plan focus on conserving cultural heritage, natural assets, tourism, and promoting the social and economic growth of the region. Within this framework, the guide is intended to aid in species monitoring, research initiatives, and tourism-related activities.

The authors are deeply grateful to the many individuals who provided guidance and support in the creation of this guide. Special appreciation goes to Ana Coelho, Duarte Gonçalves, Fulvio Licata, Jaime Sousa, László Patkó, Margareta Lakušić, Martina Panisi, Mohammad Darwish, Nuno Ferrand, Sophia Rosa, Vidak Lakušić, Yuri Simone and the conservation rangers for their contributions in gathering mammal data. Thanks are also extended to Davina Falcao for her outstanding illustrations. Additionally, the authors acknowledge the assistance of Nina Serén, Ana Ramos, Sofia Mourao, Patrícia Ribeiro, Diana Castro, Sara João, and Susana Lopes in laboratory work; Neil Rowntree and Udo Schutte for supplying habitat reference photos; and Alaaeldin I Soultan, Ayman A. Abdulkareem, Ingrid Stirnemann, László Patkó, and the RCU for their support during fieldwork in AlUla. Finally, the authors express their gratitude to the residents of AlUla for their hospitality and to the RCU for commissioning and overseeing the guide's production.

2. How To Use This Guide

The field guide is structured to provide general information about the AlUla region and mammals, followed by a brief description and illustration of all of the species recorded so far.

Chapters 3 and 4 provide a synoptic overview of the geographical and ecological context of AlUla, describing the topography, its diverse biomes and habitats, climate and weather conditions, and designated conservation areas.

It is followed by a glossary and list of abbreviations that will help navigate the guide (Ch. 5), an overview of mammals' biology and diversity (Ch. 6), with a focus on the families and species inhabiting the AlUla region, and an illustrated section (Ch. 7) that will guide the readers in the first steps in the identification of mammals at the family and genus levels through the use of relevant diagnostic morphological traits.

Chapter 8 contains detailed information accompanied by line-art illustrations for the 48 mammal species present in the AlUla region. Species are listed according to the phylogenetic order provided in Chapter 6. For each species, it provides:

- the common and scientific names;
- the global distribution;
- the distribution in AlUla, including the elevation range and the conservation areas where the species was observed. For species not observed within the conservation areas, it provides an approximate indication of the locality of the observation. Historical observations are mentioned in the cases of Cheetah, Arabian Leopard, Arabian Oryx and gazelles;
- a map with a prediction of the occurrence probability of the species in the AlUla region. Occurrence probabilities for each species were mapped based on the definition of the climatic envelope (i.e., the set of climatic conditions within which the species is predicted to occur where the environmental requirements are suitable for the species to live and survive). In the current case, the climatic envelope was defined based on the Normalised Difference Vegetation Index and Land-Surface Temperature derived by remote sensing

where the species currently occurs in the AlUla region. Averages for both variables were estimated based on the observational data for each species and mapped as occurrence probabilities at 1 km spatial resolution;

- the body measurements of the animal (body length, forearm length, ear length, hindfoot length, tail length and body weight);
- the most relevant identification traits: fur texture, colouration, and pattern; shape and proportions of body parts; pattern of the hindfoot sole; visible differences between sexes (anogenital distance, presence of nipples) and age groups (body size and body parts proportions);
- the typical habitat and habits, including activity pattern (diurnal, crepuscular, or nocturnal), and most peculiar life and natural history aspects;
- an evaluation of abundance indicating the likelihood of encountering each species in the wild, based on the number of sites at which the species was observed. The categories used are abundant (observed in more than 25 sites), common (11 to 25 sites), scarce (2 to 10 sites), rare (1 single site), and not evaluated (when it was not possible to determine the abundance); and
- the conservation status, following International Union for Conservation of Nature (IUCN) criteria, evaluated at the global and regional levels. The latter was based on the last available assessment for mammals of the Arabian Peninsula.

Chapter 9 identifies the important areas for mammal conservation in the AlUla region based on the distribution of mammal species richness at 1 km spatial resolution. The estimated species richness was calculated from the sum of the individual distribution maps for each species displayed in Chapter 8.

Chapter 10 provides an overview of the echolocation characteristics associated with each of the 18 bat species, containing sonograms, pulse/call properties (FMaxE, Fstart, Fend, Duration and Shape) and a table summarising information.

Chapter 11 provides a synthetic checklist of the mammals of AlUla, including species names and conservation status.

Lastly, the book concludes with the bibliographical references suggested for further reading (Ch. 12) and an Index (Ch. 13).

Data for the production of this field guide was based on fieldwork performed by the BIODESERTS research group and available literature. The fieldwork comprised four sampling missions in November/

December 2022, January/March 2023, May/June 2023, and October/November 2023, to collect species distribution data in 120 sampling sites. The missions aimed to cover the distinct climatic conditions experienced in the AlUla region throughout the year, thus representing the variability in the activity patterns of mammals across the different seasons. The field sampling scheme encompassed the environmental variability of the AlUla region.

The sampling of non-volant small mammals (mainly rodents) involved setting Sherman traps throughout the afternoon (concluding before sunset) at suitable locations, preferentially indicative of rodent activity (e.g., rocky spots with many crevices, burrow entrances, sandy areas with tracks, places with remnants of food items and rodent faeces, etc.). The baited traps were checked the following morning, immediately after sunrise, to ensure that captured specimens did not remain trapped inside the cages during hours of high temperatures. Also, survey spotlights were used to locate animals at night, and hand nets were employed for capturing non-volant small mammals. Captured specimens were photographed, and their faeces and ear tissue samples were collected for genetic laboratory analysis. Standard external body measurements and relevant body characteristics were recorded before releasing each specimen at its capture site.

For recording the presence of medium and large-sized mammals, camera traps were set throughout the afternoon (concluding before sunset) and collected the following morning. Alongside live- and camera-trapping, their presence was assessed by visual encounter surveys, which were performed at night, mainly on foot, and sporadically by driving when terrain conditions were suitable. Concomitantly, scats attributable to non-domestic mammals, along with occasional other remains, such as skeletal elements and soft dried organic tissues from deceased animals, were collected for genetic laboratory analysis. Additionally, acoustic surveys targeting specific large-sized species, such as the Grey Wolf, were performed. Data on the presence of these species was also gathered by conducting opportunistic interviews with locals.

The sampling of bats consisted of inspecting roosts, employing mist-nets at dusk in areas with water bodies and at the entrance of roosts, and placing five bat detectors (AudioMoth recorders) in each sampling site, recording for six hours after sunset. Captured bat specimens were identified and counted, and their calls were recorded on hand-release to build an acoustic reference library to assist in the analysis of the recordings collected with bat detectors. Recorded bats were identified to the species level or to a specific sonotype (group of species with similar

calls) by using several sound metrics, namely frequency of maximum energy (FMaxE), minimum frequency, duration, and shape of the call.

In addition, distribution data was collected from available literature, online databases (e.g., Global Biodiversity Information Facility data portal) and local collaborators.

3. Map of AlUla

The region of AlUla is located in north-western Saudi Arabia, encompassing distinct, important habitats and containing relevant floral and faunal diversity (**Figure 1**). To safeguard the natural heritage in the region, 12 conservation areas have been gazetted: the Nature Reserves of Harrat Uwayrid, Wadi Nakhlah, AlGharameel, Harrat AlZabin and Sharaan, the mountains of Jabal Nahar, Jabal Al Ward and Jabal Shayhoub, the National Geopark of Harrat Khaybar, and the Oases of AlUla, Old Khaybar and Tayma (**Table 1**).

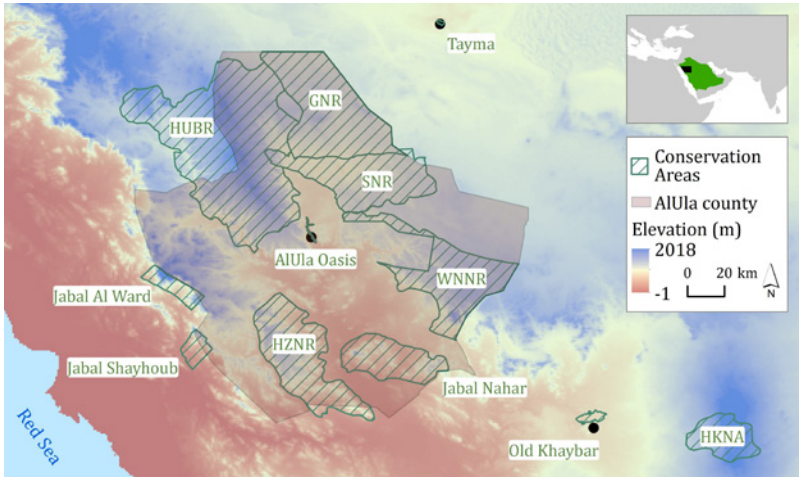
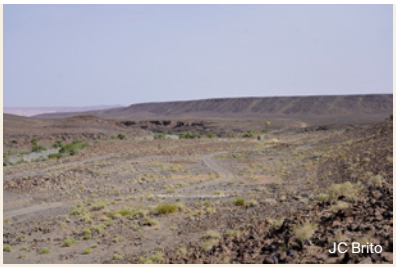


Figure 1 Location of AlUla, major urban areas, and conservation areas for the protection of natural values and ecological heritage in the county.

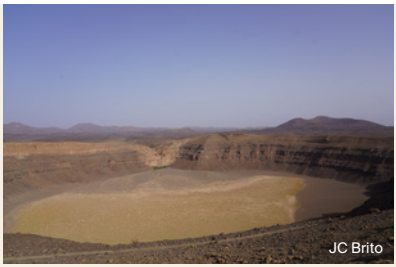
Table 1 Conservation areas within the AlUla region.

Acronym	Name	Category	Area (km²)
HUBR	Harrat Uwayrid	Biosphere Reserve	4,680
WNNR	Wadi Nakhlah	Nature Reserve	1,602
GNR	AlGharameel	Nature Reserve	2,115
HZNR	Harrat AlZabin	Nature Reserve	1,677
SNR	Sharaan	Nature Reserve	1,550
HKNA	Harrat Khaybar	National Geopark	600
JNAH	Jabal Nahar	Special Conservation Area	883
JWAR	Jabal Al Ward	Special Conservation Area	251
JSHA	Jabal Shayhoub	Special Conservation Area	174
OKHA	Old Khaybar	Special Conservation Area	56
ALUO	AlUla Oasis	Special Conservation Area	10
TAYM	Tayma	Special Conservation Area	6

Figure 2 shows photographs representing the landscapes found in the conservation areas of the AlUla region.



Harrat Uwayrid: *wadi* in rocky basalt plateau – Site 001



Harrat Uwayrid: sandy volcano crater – Site 023

Wadi Nakhlah: sandy *wadi* and rock outcrops – Site 075

Wadi Nakhlah: sandy *wadi* and rocky hills – Site 080

AlGharameel: rock outcrops in sandy desert – Site 044

AlGharameel: sandy desert and sandstone outcrops – Site 057

Harrat AlZabin: rocky plateau and outcrops – Site 095

Harrat AlZabin: rocky *wadi* and outcrops – Site 097

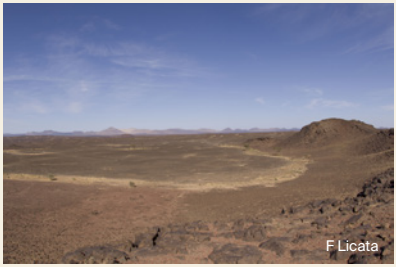
Sharaan: sandy valley and sandstone outcrops – Site 059

Sharaan: sandy valley and sandstone outcrops – Site 070

Jabal Nahar: basalt outcrops – Site 128

Jabal Nahar: sandy valley – Site AH060

Harrat Khaybar: rocky *wadi* in basalt plateau – Site 143



Harrat Khaybar: basalt plateau – Site 144

Jabal Al Ward: rocky *wadi* in basalt mountain – Site 118

Jabal Al Ward: basalt plateau – Site 198

Jabal Shayhoub: rocky *wadi* in basalt mountain – Site 119

Jabal Shayhoub: rocky *wadi* in basalt mountain – Site 122

Old Khaybar: oasis – Site 140

Old Khaybar: irrigation channels in oasis – Site 140

AlUla Oasis: oasis – Site 150

AlUla Oasis: oasis – Site 153

Tayma: oasis – Site 136

Tayma: *sabkha* – Site 136

Figure 2 Photographs of the main landscapes found in the conservation areas of the AlUla region, and associated mammals that can be found at each site.

Harrat Uwayrid	S001:	*Acomys dimidiatus, Barbastella leucomelas, Paraechinus aethiopicus, Rhinolophus clivosus, Rhinolophus hipposideros, Tadarida aegyptiaca, Tadarida teniotis, Vulpes vulpes*;
	S023:	*Felis lybica, Meriones crassus, Tadarida aegyptiaca, Taphozous nudiventris, Vulpes vulpes*.
Wadi Nakhlah	S075:	*Acomys dimidiatus, Acomys russatus, Asellia tridens, Barbastella leucomelas, Gerbillus cheesmani, Gerbillus nanus, Jaculus loftusi, Miniopterus pallidus, Paraechinus aethiopicus, Plecotus christii, Psammomys obesus, Rhinolophus clivosus, Rhinolophus hipposideros, Tadarida aegyptiaca, Tadarida teniotis, Taphozous nudiventris, Vulpes vulpes*;
	S080:	*Acomys russatus, Gerbillus cheesmani, Jaculus loftusi, Paraechinus aethiopicus, Rhinolophus clivosus, Rhinolophus hipposideros, Tadarida aegyptiaca, Taphozous nudiventris, Vulpes vulpes*.

AlGharameel	S044:	*Acomys dimidiatus, Canis lupus, Felis lybica, Lepus capensis, Paraechinus aethiopicus, Rhinolophus clivosus, Rhinolophus hipposideros, Tadarida aegyptiaca, Tadarida teniotis, Vulpes vulpes*;
	S057:	*Gazella arabica, Gerbillus cheesmani, Paraechinus aethiopicus, Vulpes vulpes*.
Harrat AlZabin	S095:	*Acomys dimidiatus, Canis lupus, Gerbillus nanus, Miniopterus pallidus, Paraechinus aethiopicus, Rhinolophus clivosus, Tadarida aegyptiaca, Vulpes vulpes*;
	S097:	*Acomys dimidiatus, Acomys russatus, Asellia tridens, Miniopterus pallidus, Myotis emarginatus, Paraechinus aethiopicus, Rhinolophus clivosus, Rhinolophus hipposideros, Sekeetamys calurus, Tadarida aegyptiaca/teniotis, Vulpes vulpes*.
Sharaan	S059:	*Acomys dimidiatus, Acomys russatus, Asellia tridens, Barbastella leucomelas, Canis lupus, Capra nubiana, Cnephaeus bottae, Felis lybica, Gazella arabica, Gerbillus cheesmani, Hypsugo ariel, Jaculus loftusi, Miniopterus pallidus, Oryx leucoryx, Paraechinus aethiopicus, Plecotus christii, Procavia capensis, Rhinolophus clivosus, Rhinolophus hipposideros, Tadarida teniotis, Vulpes vulpes*;
	S070:	*Acomys dimidiatus, Gazella arabica, Oryx leucoryx, Procavia capensis, Psammomys obesus, Rhinolophus clivosus, Rhinolophus hipposideros, Rhinopoma cystops, Tadarida teniotis, Vulpes vulpes*.
Jabal Nahar	S128:	*Acomys dimidiatus, Acomys russatus, Capra nubiana, Gerbillus nanus, Procavia capensis, Rhinolophus hipposideros, Sekeetamys calurus, Vulpes vulpes*.
Harrat Khaybar	S143:	*Canis lupus, Lepus capensis, Rhinolophus clivosus, Rhinolophus hipposideros, Vulpes vulpes*;
	S144:	*Acomys dimidiatus, Acomys russatus, Asellia tridens, Gerbillus nanus, Miniopterus pallidus, Nycteris thebaica, Paraechinus aethiopicus, Rhinolophus clivosus, Rhinolophus hipposideros, Tadarida aegyptiaca, Vulpes vulpes*.
Jabal Al Ward	S118:	*Miniopterus pallidus, Otonycteris hemprichii, Procavia capensis, Rhinolophus clivosus*;
	S198:	*Acomys dimidiatus, Cnephaeus bottae, Hypsugo ariel, Miniopterus pallidus, Rhinolophus clivosus, Rousettus aegyptiacus, Sekeetamys calurus, Tadarida aegyptiaca, Tadarida teniotis, Vulpes vulpes*.

Jabal Shayhoub	S119:	*Nycteris thebaica, Procavia capensis, Rhinolophus hipposideros, Tadarida teniotis, Vulpes vulpes*;
	S122:	*Acomys dimidiatus, Acomys russatus, Miniopterus pallidus, Paraechinus aethiopicus, Procavia capensis, Rhinolophus hipposideros, Tadarida aegyptiaca, Taphozous nudiventris, Vulpes vulpes*.
Old Khaybar	S140:	*Acomys dimidiatus, Acomys russatus, Asellia tridens, Gerbillus nanus, Miniopterus pallidus, Mus musculus, Myotis emarginatus, Paraechinus aethiopicus, Pipistrellus kuhlii, Rhinolophus clivosus, Rhinopoma cystops, Rousettus aegyptiacus, Tadarida aegyptiaca, Taphozous nudiventris*.
AlUla Oasis	S150 + S153:	*Acomys russatus, Barbastella leucomelas, Miniopterus pallidus, Paraechinus aethiopicus, Procavia capensis, Rhinolophus clivosus, Rousettus aegyptiacus, Tadarida aegyptiaca, Tadarida teniotis, Vulpes vulpes*.
Tayma	S136:	*Canis lupus, Miniopterus pallidus, Myotis emarginatus, Paraechinus aethiopicus, Rousettus aegyptiacus, Tadarida aegyptiaca, Taphozous nudiventris, Vulpes vulpes*.

4. Geography, Climate and Habitats

The AlUla region is located in the northern sector of the Hijaz Mountain range of the Arabian Peninsula, between latitudes 25°30' and 27°40' and longitudes 37°00' and 40°50'. It covers an area of about 22,500 km^2, of which about 50% is included in conservation areas. The AlUla region is fully encompassed in the Palaearctic Realm, and most of it comprises the Biome Deserts & Xeric Shrublands and has an exceptional biogeographical position in the transition zone between four Ecoregions: the Arabian desert, North Arabian desert, Red Sea-Arabian Desert shrublands, and Deserts & Xeric Shrublands. In addition, parts of the Jabal Al Ward are included in the Biome Mediterranean Forests, Woodlands & Scrub and are part of a fifth Ecoregion: Eastern Mediterranean conifer-broadleaf forests. The AlUla region is located halfway between two global biodiversity hotspots: the Mediterranean Basin and the Horn of Africa (which includes a section in the south-western Arabian Peninsula).

Topography

The Hijaz Mountain range dominates the landscapes of the AlUla region, with the altitude of the summits reaching 1,958 m on Harrat Khaybar, 1,940 m on Jabal Al Ward, and 1,711 m on Harrat Uwayrid (**Figure 3**). The conservation areas located in the Hijaz Mountains are topographically heterogeneous, and elevation in Harrat Uwayrid, Harrat AlZabin, Jabal Al Ward, Jabal Shayhoub and Jabal Nahar spans over 1,000 m between the lowland areas and the mountainous summits. By way of contrast, the oases of AlUla, Tayma and Old Khaybar are located between 600 m and 800 m in elevation and are generally flat, following the courses of riverbeds. The conservation areas of AlGharameel, Sharaan and Wadi Nakhlah are located on the north-western extreme of the Great Nafud sands, where the altitude ranges from 650 m up to 1,500 m.

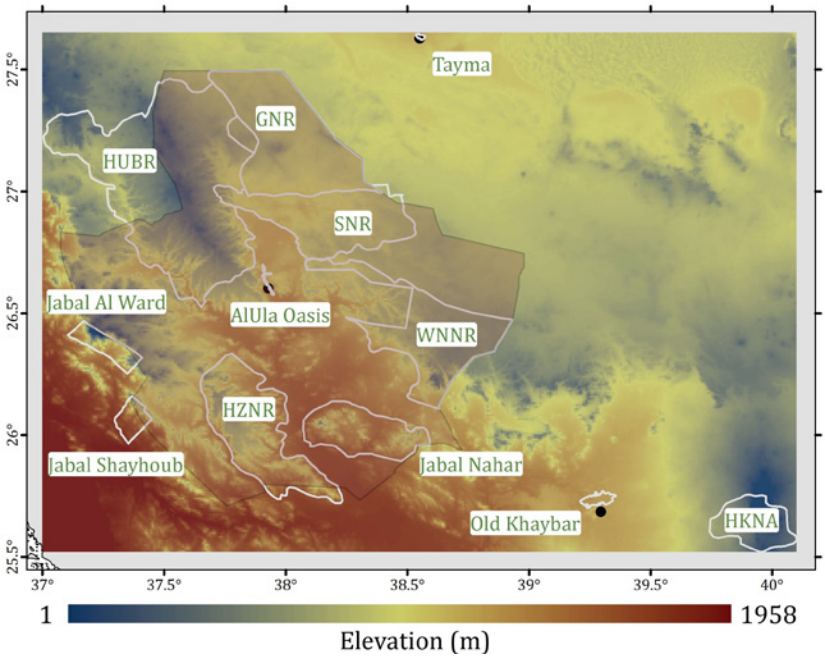


Figure 3 Elevation in the AlUla region. AlUla County (grey polygon), major urban areas (black dots), and conservation areas (white polygons) are identified.

Climate

The AlUla region comprises one of the most arid parts of the Arabian Peninsula. In the city of AlUla, the summers are long, sweltering, arid and clear, and the winters are short, cool, dry and mostly clear. The average temperature typically varies from a minimum of 3 °C up to a maximum of 38 °C, and is rarely below 0 °C or above 40 °C. The hot season lasts four months, from June to September, with an average daily high temperature above 35 °C. The hottest months are August and September, with an average high of 38 °C and a low of 20-22 °C. The cool season lasts three months, from December to February, with an average daily high temperature below 24 °C. The coldest months of the year are January and February, with an average low of 4-5 °C and a high of 21-22 °C. There is no significant seasonal variation in the frequency of wet days (i.e., days with precipitation above 1 mm). Thus, the quantity of rainfall does not vary significantly over the year. The highest rainfall is recorded in January, with an average total rainfall of 2.9 mm, followed

by December, February and March, with average total rainfall of 1.7 mm. The average total rainfall from June to August is 0 mm.

Annual average temperature within the AlUla region follows a latitudinal gradient, where southern regions are warmer, and the temperature may reach up to 26.8 °C. In comparison, northern regions are cooler, and the temperature may drop to 17 °C. Within the conservation areas, Jabal Nahar and Old Khaybar exhibit the highest annual average temperatures (around 25 °C). In contrast, Harrat Uwayrid, AlGharameel, Sharaan and Jabal Al Ward exhibit the coldest annual average temperatures (around 20-21 °C). The highest amplitude in annual average temperature within the conservation areas is recorded in Harrat Uwayrid (5.3 °C) and Jabal Al Ward (6.3 °C).

Average total precipitation within the AlUla region follows a longitudinal gradient, where eastern regions are wetter and precipitation may reach up to 154 mm/year. In comparison, western regions are drier, and precipitation may drop to 32 mm/year. Within the conservation areas, Wadi Nakhlah and Harrat Khaybar exhibit the highest average total precipitation (84 and 125 mm/year, respectively). In contrast, Jabal Shayhoub and the AlUla Oasis exhibit the lowest average total precipitation (52 and 60 mm/year, respectively). The highest amplitude in average total precipitation within the conservation areas is recorded in Jabal Al Ward (67 mm/year) and Harrat Khaybar (53 mm/year).

Land cover

The AlUla region comprises eight main land cover categories (**Figure 4**): 1) Rocky mountain (32.8%) covering most of Jabal Al Ward, Jabal Nahar, Jabal Shayhoub, Harrat AlZabin, Harrat Uwayrid, southern Harrat Khaybar, and southern Wadi Nakhlah; 2) Sand and stony flatlands (30.4%) covering most of Sharaan, southern AlGharameel, and northern Wadi Nakhlah; 3) Stony flatland (13.4%) covering lowland areas surrounding the mountain areas; 4) Sandy flatland (12.3%) covering AlGharameel and Sharaan; 5) Sandstone (9.3%) covering most of AlGharameel, Sharaan, western Harrat Uwayrid, and northern Wadi Nakhlah; 6) Volcanic rock (1.3%) covering most of Harrat Khaybar; 7) Salt pan (0.3%) covering parts of Tayma; and 8) Oasis (0.2%) covering the oases of AlUla, Tayma and Old Khaybar.

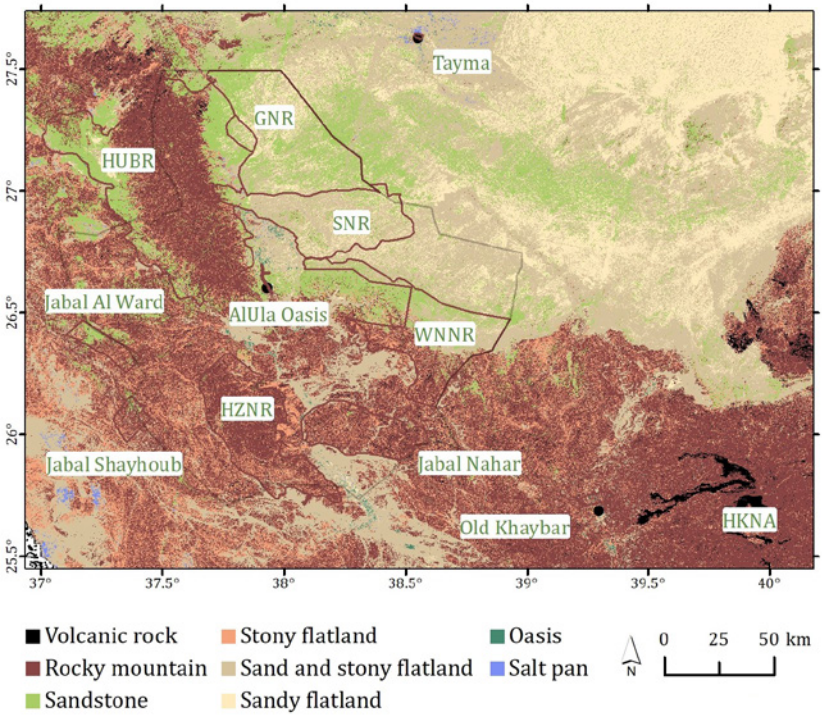


Figure 4 Main land-cover categories found in the AlUla region. AlUla County (grey polygon), major urban areas (black dots) and conservation areas (brown polygons) are identified.

Environmental variation

The environmental variation within the AlUla region is mostly related to the availability of water and types of land cover (**Figure 5**). Five broad environmental units can be identified within the conservation areas of the AlUla region: 1) the north-eastern barren or sandy plains (blue colouration) dominating AlGharameel, Sharaan and the northern and eastern sectors of Wadi Nakhlah; 2) the vegetated areas along the oases of AlUla, Old Khaybar and Tayma, and the plateaux of Harrat AlZabin (pink colouration); 3) the south-western mountain areas of Jabal Al Ward and Jabal Shayhoub, and parts of Jabal Nahar (yellow-green colouration); 4) the rocky mountains of Harrat AlZabin, Harrat Uwayrid, and the southern sector of Wadi Nakhlah (brown-green colouration); and 5) the volcanic lava fields of Harrat Khaybar (light blue colouration).

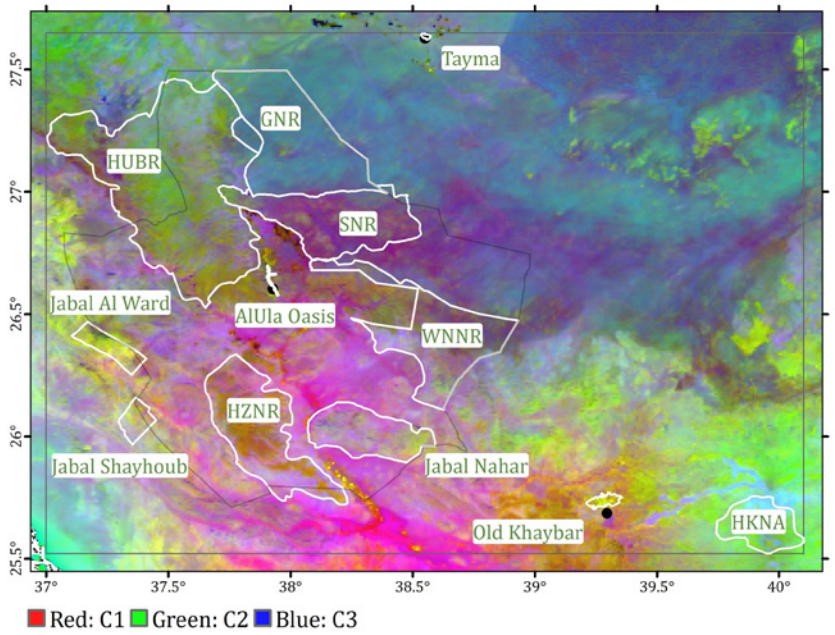


Figure 5 Environmental variability in AlUla County depicted by Harmonic Regression. Scaled coefficients (depicted in RGB colour palette) represent variation in the Normalised Difference Vegetation Index (NDVI; 250m resolution; MODIS satellite) along 2011-2020. AlUla County (grey polygon), major urban areas (black dots) and conservation areas (white polygons) are identified.

5. Glossary, Abbreviations and Map Symbology

Technical words, abbreviations and map symbols used in the Field Guide.

Glossary

Adit: Horizontal passage or tunnel into underground mine.

Aerial hawking: Foraging strategy involving the capture of prey mid-air.

Anterior: Near the front end of the body.

Arboreal: Living in trees.

Biodiversity hotspot: Threatened area with high species richness.

Biome: Major habitat type.

Bipedal saltatorial locomotion: Whole-body movement performed by jumping with two legs.

Breeding season: Reproductive period.

Broadband pulse: Pulse that occupies a broad range of frequencies.

Browser: Feeding on leaves, flowers, fruits, and other high-growing vegetation.

Burrow: Underground animal shelter.

Calcaneus: Tarsal bone that forms the heel of the foot.

Canid: Carnivore member of the family Canidae (e.g., dogs, wolves, foxes, jackals, coyotes).

Canine: Conical, pointed tooth.

Carnassial teeth: Meat-shearing teeth.

Carnivorous: Feeding on meat.

Cathemeral: Active day and night.

Colony: Group of closely associated individuals of the same species, often exhibiting structured or cooperative behaviour.

Commensal: Benefiting from another organism without harming or benefiting it.

Communal nesting: Group-living in a shared nest.

Congener: Species belonging to the same genus as another species.

Conspecific: Individual belonging to the same species as another individual.

Constant frequency (CF): Component of a bat pulse that remains at one frequency over the entire call duration.

Crepuscular: Active at dawn/dusk.

Cryptic species: Morphologically identical species that can only be differentiated by genetic analyses.

Cucurbit: Vine/gourd plant of the family Cucurbitaceae (e.g., pumpkins, squash, cucumbers, melons).

Cursorial locomotion: Whole-body movement performed by running.

Dentition: Tooth arrangement.

Diurnal: Active during the day.

Duration: Duration of a bat pulse.

Echolocation: Use of ultrasound and the returning echoes to orient and navigate in the environment.

Ecoregion: Region with specific ecological features.

Ecosystem: Community of living organisms and their environment.

Felid: Carnivore member of the family Felidae (e.g., cats, lions, tigers, leopards, cheetahs).
Fend: Ending frequency of a bat pulse.
Endemic: Native or confined to a particular region.
Feral: Domesticated animal that has returned wild.
FMaxE: Frequency of maximum energy of a bat pulse (peak frequency).
Forage: Search for and obtain food.
Fossorial: Living underground and adapted for burrowing.
Frequency modulated (FM): Component of a bat pulse that varies or 'modulates' in frequency throughout the call.
Frugivorous: Primarily feeding on fruits.
Fstart: Starting frequency of a bat pulse.
Genus: Taxonomic rank in the biological classification between the family and the species levels. The genus forms the first part of the binomial species name.
Gerbil: Small, burrowing rodent with long hind legs of the murid subfamily Gerbillinae, which also includes jirds and sand rats.
Gestation: Pregnancy duration.
Granivorous: Feeding on seeds.
Grazer: Feeding on grasses and other low-growing plant types.
Gregarious: Living in groups, social.
Halophytic: Salt-tolerant (specifically referring to plants).
Hammada: Rocky plateau.
Harmonic: Bat pulses can be composed of a primary component, called the fundamental or first harmonic, as well as higher components that occur at whole number multiples of the fundamental, called upper harmonics (e.g., second harmonic).
Harrat: Basaltic lava field.
Heglig: Desert date.
Herbivorous: Feeding on plant material.
Heterodont: Dentition consisting of multiple tooth types.
Heterothermy: Physiological condition of variable body temperature.
Hibernation: Prolonged state of reduced metabolic rate, body temperature and behavioural activity.
Hind limb: Back leg.
Home range: Area of daily activity.
Homeothermy: Physiological condition of stable body temperature.
Hymenoptera: Order of insects such as ants, bees, wasps, and sawflies.
Incisor: Front, chisel-like tooth.
Insectivorous: Feeding on insects.
Jird: Rodent resembling gerbils but generally larger, and belonging to the murid subfamily Gerbillinae, which also includes gerbils and sand rats.
Laurasian: Relative to Laurasia, the Mesozoic supercontinent including North America, Europe, and Asia.
Malleus, incus, stapes: Three small bones inside the ear collectively known as the ear ossicles, unique to mammals.
Mammary gland: Specialized gland type unique to mammals that produces milk to nourish offspring.
Mane: Long neck hair.
Marsupium: Anatomical structure consisting of a maternal pouch unique to marsupials, used to nurture and protect the developing young.

Maternity colony: Colony dominated by females and juveniles.
Melanism: Dark pigmentation.
Mesic: Moderately moist.
Migratory: Moving seasonally to relocate to favourable areas.
Molar: Broad, flat tooth for crushing and grinding food.
Monoestrous: With one breeding cycle per year.
Monophyletic: Deriving from a single common ancestor.
Murid: Rodent member of the family Muridae.
Mustelid: Carnivore member of the family Mustelidae (e.g., weasels, badgers, otters, ferrets, martens).
Narrowband pulse: A pulse generated by bats that occupies a narrow range of frequencies.
Near-endemic: Mostly, but not exclusively, found in a specific area.
Nocturnal: Active at night.
Nomadic: Roaming, not settled, with an undefined home range.
Noseleaf: Fleshy, leaf-shaped structure on the nose of some bats, helping focus the sounds they use for echolocation.
Omnivorous: Feeding on both plants and animals.
Oviparous: Laying eggs that develop and hatch outside the maternal body.
Palaearctic realm: Biogeographic region including Eurasia and North Africa.
Pelage: Mammal fur, hair or wool.
Phylogeny: Evolutionary history of related lineages.
Plantigrade: Moving with the foot's sole and heel touching the ground.
Polyestrous: Able to reproduce multiple times throughout the year or breeding season.
Premolar: Crushing, grinding tooth. Premolars are positioned before molars.
Pulse: Term typically used when describing bat vocalisations. A single pulse is also known as a bat call. Multiple pulses make up a pulse sequence, also known as a bat pass.
Quasi-constant frequency (QCF): Component of a bat pulse that varies only through a narrow frequency throughout the call.
Riparian: Associated with riverbank habitats.
Roost: Rest or sleep site.
Sabkha: Salt-encrusted mudflat or sand flat located in internal, closed drainage basins, but also often found near sea coasts and usually in hot, dry regions.
Sampling: Data/specimen collection process.
Sanguinivory: Dietary habit consisting of feeding on blood.
Scrubland: Arid habitat with vegetation consisting of shrubs, herbs, grasses.
Sedentary: Non-migratory.
Sexual dimorphism: Sex-based difference.
Species richness: Species count of an area.
Steppe: Grassland plain without trees.
Striated: Marked with long, parallel lines, bands, or streaks.
Taxonomy: Scientific discipline focusing on naming and classifying organisms based on shared characteristics.

Terrestrial: Living on the ground.
Territorial: Defending a specific territory.
Testicondy: Condition of having undescended testes.
Torpor: Temporary state (usually <24 h) of reduced metabolic rate, body temperature and behavioural activity.
Tragus: Small flap of cartilage at the entrance to the ear canal.
Tufted tail: Tail with bushy end.
Tympanic bullae: Ear bone structures.
Underparts: Underside of the body, primarily consisting of belly and chest.
Ungulate: Terrestrial hoofed quadruped member of the orders Cetartiodactyla (e.g., pigs, camels, giraffes, deer, cows, hippos; also referred to as even-toed ungulates) and Perissodactyla (e.g., horses, donkeys, rhinos, tapirs; also referred to as odd-toed ungulates).
Uropatagium: Leathery sheet of skin stretching between the bat's hind limbs and often incorporating the tail.
Vibrissae: Whiskers.
Wadi: River valley or ephemeral riverbed.
Xeric: Very dry, arid.

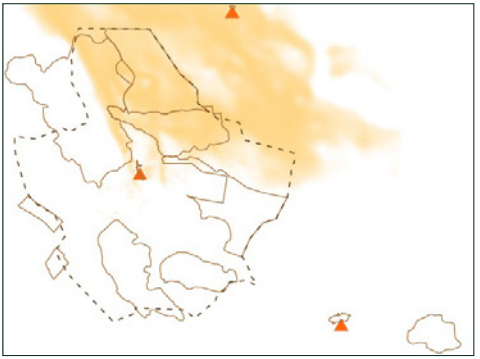
Abbreviations

a.s.l.	above sea level
BW	body weight
C	number of canines
c.	circa
cm	centimetres
CR	Critically Endangered (IUCN Red list criteria)
DD	Data Deficient (IUCN Red list criteria)
DF	dental formula
e.g.	for example
EL	ear length
et al.	and others
F	female
FA	forearm length
HFL	hindfoot length
HL	horn length
I	number of incisors
i.e.	that is
IUCN	International Union for Conservation of Nature
km	kilometres
LC	Least Concern (IUCN Red list criteria)
M	male
m	metres
ML	number of molars
mm	millimetres
NA	Not Applicable for conservation status assessment (IUCN Red list criteria)
NE	Not Evaluated (IUCN Red list criteria)
NT	Near Threatened (IUCN Red list criteria)
P	number of premolars
SH	shoulder height
RE	Regionally Extinct (IUCN Red list criteria)
TBL	total body length
TL	tail length
UAE	United Arab Emirates
vs	versus
VU	Vulnerable (IUCN Red list criteria)

Map symbology

In the distribution maps for each species:

- dashed polygon: AlUla County
- brown polygons: conservation areas
- orange triangles: cities
- yellow shading: areas of probability of species occurrence, where darker tones indicate a higher occurrence probability.



6. Mammal Taxonomy

Taxonomic names are assigned through an analytical process dependent on phylogeny – the history of the evolution and relationships of living beings. This guide follows the most updated taxonomy and nomenclature of the world's mammals, taken from the 'Mammal Diversity Database' (v1.12.1, accessed on March 7th 2024), a comprehensive mammal taxonomy database maintained by the American Society of Mammalogists (ASM) and curated by Nate Upham, Connor Burgin, Jane Widness, Madeleine Becker, Jelle Zijlstra and David Huckaby; and the resource 'Bat Species of the World: A taxonomic and geographic database', compiled and edited by Nancy B. Simmons and Andrea L. Cirranello from the American Museum of Natural History. For consistency, the common names were selected from the same source or adopted when unavailable according to their etymology. To avoid controversial taxonomic entities, the guide does not include subspecies of mammals (a category in biological classification that ranks immediately below a species). The exception to this was the Arabian Leopard due to its conservation priority in AlUla.

The Class Mammalia

Mammals encompass diverse groups, such as bats, primates and cetaceans, and include 6,718 species, according to the most recent estimate. The class Mammalia constitutes a monophyletic group; thus, all mammal species have descended from a common ancestor. This shared origin is evidenced by distinctive traits common to all mammals: three ossicles in the middle ear (the malleus, incus and stapes), heterodont dentition for efficient collection and initial processing of food, mammary glands derived from modified sweat glands for milk production in females, endothermy (the ability of an organism to regulate its body temperature through internal metabolic processes), and the presence of hair or fur, which are unique epidermal structures. The insulation provided by this integumentary cover, combined with endothermy, allows many mammalian species to maintain high and relatively stable body temperatures independently of environmental temperature fluctuations, homeothermy. This type of temperature regulation, shared with birds

(among some other species), is crucial for sustaining high levels of activity across a range of environmental temperatures. Endothermy is believed to have coevolved and is tightly associated with many other mammalian traits, such as elevated metabolic rates (approximately ten times that of reptiles), a well-developed brain for sensing and processing environmental stimuli, complex behaviours, extensive pre- and post-natal parental care, and elaborate mating systems. These traits have allowed mammals to colonise most of Earth's habitats and occupy diverse ecological niches.

Mammals are classified into three major groups based on their reproductive strategies and shared phylogenetic history:

- Monotremes (Order Monotremata) represent an ancient, relict mammal lineage. This distinctive group comprises the unique duck-billed platypus and echidnas, endemic to Australia, Tasmania, and New Guinea. Monotremes retain unique traits not observed in other mammals: oviparous reproduction mode, cloaca for both excretory and reproductive functions, and mammary glands without nipples.
- Marsupials (Infraclass Marsupialia) encompass around 416 species distributwed mainly among Australia, New Guinea, New Zealand, and South America. This group includes iconic representatives such as kangaroos, wallabies, koalas, and opossums. The hallmark feature of marsupials is the marsupium, an external fold of skin located on the abdomen of females. This structure shelters and nourishes the underdeveloped young.
- Placentals (Infraclass Eutheria) represent the most diverse mammalian lineage, with over 6,289 species. They are distributed worldwide, except for a few remote or inhospitable regions and Antarctica. The defining feature of the group is the sophisticated placenta, which supports the developing foetus. The prolonged gestation period of placentals results in the birth of young at a more advanced developmental stage compared to monotremes and marsupials.

Mammals found in Saudi Arabia

While Saudi Arabia does not host any native or invasive monotreme or marsupial species, it is home to a diverse range of placental mammals. These mammals belong to three of the four placental superorders: Afrotheria, Euarchontoglires, and Laurasiatheria.

Afrotheria, a clade of African origin whose species currently reside mainly on this continent, encompasses 89 species divided among six distinct orders: Tubulidentata, Afrosoricida, Macroscelidea, Hyracoidea, Proboscidea, and Sirenia. Members of this superorder exhibit peculiar genetic and morphological traits, such as an increased number of thoracolumbar vertebrae and testicondy (i.e., the condition where the testes do not fully descend into the scrotum). In Saudi Arabia, only one afrotherian species is found: *Procavia capensis*, which belongs to the single family Procaviidae within the order Hyracoidea.

- Family Procaviidae [3 genera, 5 species]. Hyraxes occur from central and Southern Africa to the Levant and Arabian Peninsula, including Saudi Arabia. They inhabit various environments, from rocky outcrops and forested areas to elevations up to 4,200 m a.s.l. These mammals are notable for their specialised foot pads that aid in climbing and a mid-dorsal gland used in social interactions. Hyraxes exhibit varied social structures, with some species forming large colonies while others are solitary and nocturnal. Their diet is primarily herbivorous. They reproduce once a year, with a gestation period of about eight months and litter sizes ranging from one to four. *Procavia capensis*, the only afrotherian species found in Saudi Arabia, is also present in the AlUla region.

Euarchontoglires, a clade of Palaearctic origin, encompasses 3,390 species divided among five distinct orders: Scandentia, Dermoptera, Primates, Lagomorpha and Rodentia. Members of Euarchontoglires share a unique combination of genetic and morphological traits, such as the characteristic conformation of their ankle bones. In Saudi Arabia, members of the orders Primates, Lagomorpha and Rodentia are found. The only primate species occurring in the country is the Hamadryas baboon (*Papio hamadryas*), which is found in the southwestern region of Saudi Arabia, but not in the AlUla region. Similarly, only one species from the order Lagomorpha, *Lepus capensis*, is present in Saudi Arabia and is known to occur in the AlUla region. In contrast, Rodentia (which includes mice, voles and squirrels), comprising 40% of all mammalian species globally, is represented in Saudi Arabia by 22 species, 12 of which occur in the AlUla region. However, these numbers are difficult to pinpoint precisely due to taxonomic revisions and ongoing discoveries. All rodents share a unique dentition specialised for gnawing, with two pairs of continuously growing incisors maintained functional by a 'self-sharpening' mechanism. Based on skull conformation and

jaw musculature, and particularly the origin of the masseter muscles, five suborders are recognised: Sciuromorpha (squirrel-shaped), Castorimorpha (beaver-shaped), Myomorpha (mouse-shaped), Anomaluromorpha (springhare-shaped) and Hystricomorpha (porcupine-shaped). The 12 rodent species found in the AlUla region belong to the families Gliridae (Sciuromorpha), Dipodidae (Myomorpha) and Muridae (Myomorpha).

- Family Gliridae [9 genera, 30 species]. Dormice are widespread across Europe, Asia, Africa and southern Japan. They occupy various habitats, from forests and shrublands to urban areas. These nocturnal, semiarboreal rodents primarily subsist on nuts, fruits and insects, and also occasionally prey on nesting birds. Their digestive system, featuring a simple stomach, reflects a diet that is poor in cellulose. Dormice are known for their communal nesting in tree cavities or buildings, and have a reproductive cycle heavily influenced by food availability, with some species entering extended hibernation periods when resources become scarce. The single species found in Saudi Arabia, *Eliomys melanurus*, also occurs in the AlUla region.
- Family Dipodidae [14 genera, 41 species]. Dipodids (jerboas) inhabit open semidesert regions from the west of northern Africa to Mongolia and north China through the Arabian Peninsula, Iranian Plateau and Central Asia. Jerboas' elongated hind limbs are instrumental in their bipedal saltatorial locomotion, while their front limbs (in some species) are used for burrowing and gathering food. These rodents are nocturnal and mainly herbivorous, subsisting on seeds, fruits, roots and succulent vegetation. However, omnivory and insectivory are not uncommon instances. Jerboas spend the daytime in burrows and may enter torpor or hibernate to withstand hot summer and cold winter periods, respectively. Some species exhibit multiple breeding seasons within a year. In Saudi Arabia, two species of Dipodidae are found, of which the species *Jaculus loftusi* occurs in the AlUla region.
- Family Muridae [162 genera, 871 species]. This vast family occupies nearly every global habitat except Antarctica, from dense forests and arid deserts to lush grasslands. Most murids weigh less than 100 grams and are nocturnal, although some species significantly deviate from this scheme by being much smaller or larger, or by exhibiting diurnal activity patterns. The diet of murids is varied and highly opportunistic, ranging from herbivory to carnivory. Reproductive

strategies are equally diverse, with some species capable of producing several large litters each year. In Saudi Arabia, 18 species of Muridae are found, of which 10 are present in the AlUla region.

Laurasiatheria encompasses 2,778 species divided among six distinct orders: Eulipotyphla, Chiroptera, Carnivora, Pholidota, Perissodactyla and Cetartiodactyla. Cetartiodactyla includes the aquatic infraorder Cetacea (whales, dolphins and porpoises) alongside its terrestrial members (even-toed ungulates, such as pigs, camels, giraffes, deer, cows and hippos). All these groups, excluding Pholidota (pangolins) and Perissodactyla (odd-toed ungulates, such as horses, donkeys, rhinos and tapirs), have native extant or reintroduced representatives inhabiting Saudi Arabia. Concerning Perissodactyla, the onager *Equus hemionus onager* has been recently introduced in place of the extinct subspecies *E. h. syriacus*. The Arabian Oryx (Cetartiodactyla), was also recently reintroduced in Saudi Arabia.

- Order Eulipotyphla [4 families, 61 genera, 594 species]. Eulipotyphla members have a cosmopolitan distribution and reside in various habitats, including forests, deserts and subterranean environments. These small- to medium-sized plantigrade mammals are distinguished by an elongated and pointy snout, molars with a W- or V-shaped occlusal pattern, small to absent external ears, and a small braincase. In some eulipotyphlans, fur is modified into spines for defence, such as in hedgehogs. Eyes may be non-functional, reflecting an adaptation to nocturnal or fossorial habits. Eulipotyphlans are primarily insectivorous. In Saudi Arabia, five species from the Erinaceidae and Soricidae families are present, of which one erinaceid (*Paraechinus aethiopicus*) is found in the AlUla region.
- Order Chiroptera [21 families, 236 genera, 1,475 species]. Bats populate every continent and major oceanic island, thriving in diverse habitats from dense forests to arid deserts. They are the only mammals capable of powered flight and can navigate and forage through echolocation, a process involving the emission and reception of sound waves. Their feeding strategies range from frugivory and nectarivory to insectivory and sanguinivory. Some bats act as pollinators or seed dispersers. Despite the overall breadth of bats' dietary habits, most species in Saudi Arabia are insectivorous, while only three are frugivorous. Complex social structures are evident in some species. Bats mainly produce one to two offspring annually,

and some species display delayed fertilisation. In Saudi Arabia, 32 species of bats are found, of which 18 occur in the AlUla region.

- Order Carnivora [16 families, 129 genera, 317 species]. Carnivorans include a broad diversity of predatory forms with varying body plans and sizes, ranging from relatively small weasels to large lions and bears. This group inhabits diverse ecosystems across the globe, including the aquatic environments colonised by pinnipeds. Carnivorans possess carnassial teeth adapted for shearing meat, which constitutes the bulk of their diet. This feature predominates in predatory and scavenging forms, although the order also encompasses omnivorous members. Carnivorans range in social behaviour from solitary hunters to pack animals. In Saudi Arabia, 15 species of carnivorans are found, of which 11 occur in the AlUla region. However, the Golden Jackal (*Canis aureus*) is not consider in the species accounts of this guide because it was detected in AlUla only recently.
- Order Cetartiodactyla [23 families, 138 genera, 365 species]. This diverse group is spread worldwide and includes well-known examples such as pigs, camels, giraffes, deer, cows, hippos, whales, and dolphins. Terrestrial cetartiodactyls, closely related to cetaceans, share a distinctive foot structure, and their limbs exhibit anatomical adaptations for cursorial locomotion. Their predominantly herbivorous diet is associated with a complex digestive system with a simple to multi-chambered stomach. These mammals generally sire one or two offspring per breeding cycle, with the exception of pigs. In Saudi Arabia, 5 species of terrestrial cetartiodactyls are found, of which 3 occur in the AlUla region. Aquatic cetartiodactyls, commonly known as cetaceans, are highly adapted to life in water, featuring streamlined bodies and limbs modified into flippers. Their diet ranges from filter-feeding to carnivory. Aquatic cetartiodactyls typically sire one offspring per breeding cycle. 15 species of aquatic cetartiodactyls are found in Saudi Arabia.

Notes on specific changes from the reference taxonomy ‘Mammal Diversity Database’:

- Cetartiodactyla – Recent taxonomic revisions have prompted the replacement of the traditional lineage name Artiodactyla with the more inclusive Cetartiodactyla in this guide. The term Cetartiodactyla accurately reflects the phylogenetic proximity of cetaceans and even-toed ungulates, which together form a

monophyletic group, whereas Artiodactyla only designates even-toed ungulates. In this guide, even-toed ungulates are also referred to as terrestrial members of the order Cetartiodactyla or artiodactyls.

7. Mammal Topography

Mammals are key components of their ecosystems, exhibiting characteristic body shapes which are often unmistakable. They are perceived as being 'closer' to mankind when compared with other animal groups, given the crucial roles they have played in human life (e.g., cattle and pets). Unsurprisingly, the knowledge of mammals, also given their importance for translational human medical research, tends to be much more advanced when compared with less 'charismatic' animals, such as worms or frogs. It is intuitively easy for anybody to distinguish a herbivore (e.g., gazelle) from a carnivore (e.g., fox or leopard). However, it is much more complex for the casual observer (and sometimes also for seasoned naturalists and specialists) to distinguish between two closely related species, even in the case of two large-sized mammals, such as different gazelles. Fortunately, most medium to large mammals in Saudi Arabia can be confidently identified by inspecting specific external morphological characteristics. In contrast, the identification of most small mammal species is impossible based on morphological criteria and without genetic analyses, even by an expert.

Body size and shape The primary and most revealing characteristics are the overall size and body shape, which can vary significantly across different mammal species. Based on size, mammals can be categorised as small (usually <100 g; many rodents and bats), medium (often ~0.5–1 kg; typically small carnivores), or large (mainly >5 kg; big-bodied carnivores, perissodactyls and artiodactyls). So, each mammal group can often be associated with a specific size category (even if these broad categories overlap). Therefore, just a rough estimate of the size of an encountered mammal can often inform us readily on the most likely group it could belong to. For instance, a small mammal spotted in a semidesert area of Saudi Arabia and estimated to weigh a few tens of grams is likely a rodent (or a shrew), whereas a sizeable horned animal spotted from a distance must be an even-toed ungulate. If a species is strongly sexually dimorphic (whereby males are typically larger than females), this trait can also help determine the individual's sex.

Relative body proportions are also crucial for a tentative identification. For example, the Cheetah's slim build and long limbs contrast sharply with the compact, robust body of the Honey Badger. Body proportions are also a reliable indicator of an individual's age within a species. Similar to humans, juveniles of other mammals frequently have large heads and limbs in proportion to their bodies.

Fur texture and colouration The texture and colour of the fur are sometimes crucial and sufficient for identification. Patterns, such as the Cheetah's distinctive 'tear lines' or the striking grey-white back contrasted with black underparts of the Honey Badger, can be highly distinguishing and species-specific. Some patterns can also be leveraged to discern juveniles from adults in certain species.

Head and facial features The shape of the head, ear size and positioning, colour and pattern around the eyes and nose, and presence/absence of vibrissae can be informative. For example, the large, low-set ears and broad, flat head of the Sand Cat are telltale features.

Other important features The tail is, in some cases, an informative diagnostic character thanks to its variability in length, colouration, patterning and, in the case of bats (see below for other features), anatomical relationship with the uropatagium. Concerning this aspect, the prominent tail of the Bushy-tailed Jird represents an emblematic example. Concerning even-toed ungulates, horns can be critical for identification, with their shape, size and pattern being typical of certain species. The hair pattern on the hindfoot's sole, together with the organisation of the sole pads, can help assign a particular rodent individual to specific taxonomic groups but not to others. Compared to other mammals, bats possess unique features, and thus specific body measurements are used to capture their distinctiveness: relative wing length and aspect ratio (long and narrow vs short and broad); conformation of the tragus and other ear structures; presence/absence and shape of the noseleaf.

If there is the opportunity to directly measure a mammal specimen, there are standard body measurements that are useful for species identification:

- Body weight (BW).
- Total body length (TBL): Distance from the tip of the nose to the tip of the fully extended tail, excluding from the latter any terminal hair tuft.

- Tail length (TL): Distance from the tail's base to its tip, excluding any terminal hair tuft. For bats, this is the distance from the pelvic base to the tip of the tail.
- Forearm length (FA; used only for bats): Distance from the elbow (i.e., the tip of the ulnar olecranon) to the wrist joint.
- Hindfoot length (HFL): Distance from the posterior part of the heel to the tip of the longest toe's fleshy portion (European convention) or the tip of the biggest claw (American convention). For bats, this is the distance from the base of the calcar, or from the calcaneum in bats that do not possess a calcar, to the tip of the longest toe (European convention) or the claw's tip (American convention).
- Ear length (EL): Distance from the notch at the base of the ear to the most distant point of the pinna (i.e. the external ear), excluding any fur or tufts at the ear's tip. For bats, this is the distance from the notch at the base of the ear to the tip of the pinna (if a tragus is present, its form and length must be recorded).
- Horn length (HL; used only for horned mammals): Distance from the base of the horn (where it emerges from the head) to the tip of the horn.
- Shoulder height (SH; used for medium-sized and large mammals): Vertical distance from the ground to the highest point of the shoulder (the withers), where the neck meets the back.

Species identification often relies on skeletal remains rather than on complete specimens. Skulls are particularly informative because each mammal lineage is characterised by a specific dental formula (DF). When a mammal mouth is figuratively divided into four quadrants (left and right halves of the upper and lower jaws), the dental formula expresses the tooth complement – the number of incisors, canines, premolars and molars – in one half of the upper and lower jaws. For example, the dental formula of the Arabian Leopard is 'I 3/3, C 1/1, P 3/2, M 1/1', indicating that this species possesses three incisors on one half of both jaws, one canine on one half of both jaws, three premolars in one half of the upper jaw and two in one half of the lower jaw, and one molar in one half of both jaws.

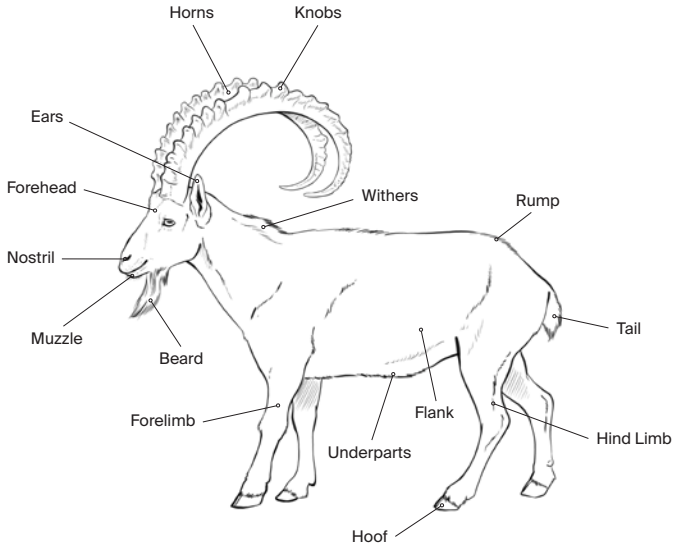


Figure 6 Lateral view of an ungulate, with the names of the main terms used for describing morphological characteristics.

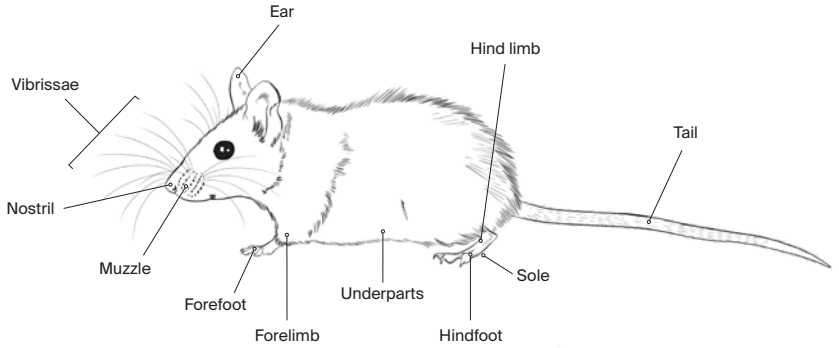


Figure 7 Lateral view of a rodent, with the names of the main terms used for describing morphological characteristics.

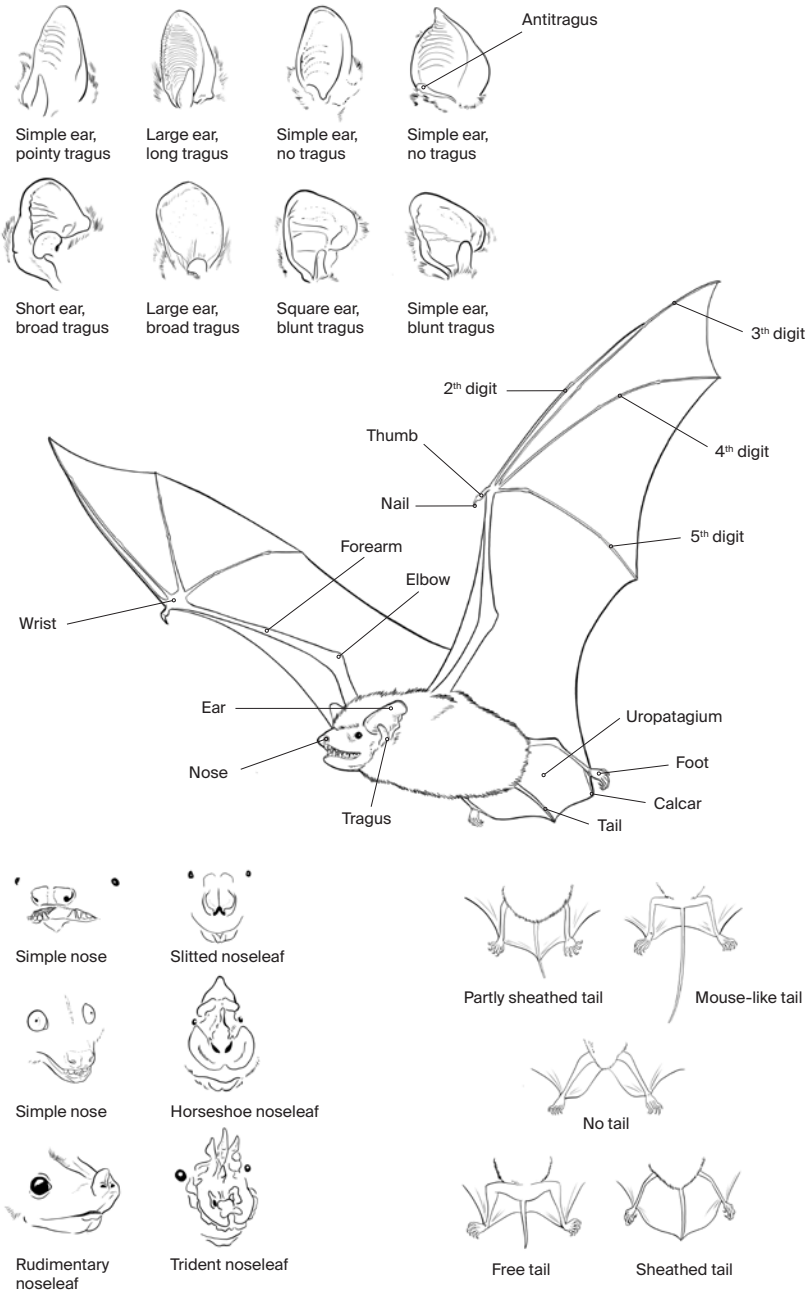
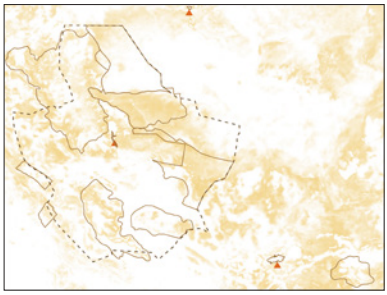


Figure 8 Bat scheme, with the names of the main terms used for describing morphological characteristics, and details on the variation in ear, nose and tail morphology.

8. Species Accounts

Rock Hyrax
Procavia capensis (Pallas, 1766)

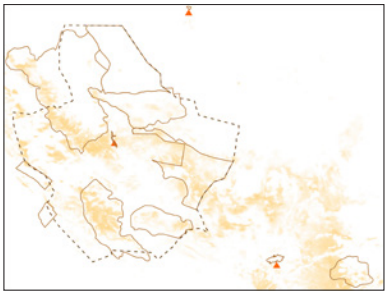


Global distribution: Sub-Saharan, NE Africa; isolated populations in Sahara. Probably occurs throughout western mountains of Arabian Peninsula from Lebanon to SW Yemen; isolated populations in Oman (Dhofar) and C Saudi Arabia.
Distribution in AlUla: Observed between 350 and 1,530 m a.s.l., can be found in all conservation areas except Old Khaybar and Tayma.
Measurements: BW: 1.8–5.4 kg; TBL: 35.7–57.4 cm; SH: 20.2–30.5 cm; HFL: 5.6–8.1 cm; EL: 2.6–4 cm; DF: I 1/2, C 0/0, P 4/3, ML 3/3.
Identification: Medium-sized, with solid build. Fur dense, yellowish-buff to dark brown; underparts slightly paler. Snout short, pointed. Nasal region hairless, black. Black vibrissae up to 180 mm. Eyes rather large, dark; pale patch above. Ears short, rounded. Neck, limbs short, sturdy. No external tail. Combined mid-dorsal gland and surrounding yellowish fur patch serve in communication with conspecifics. No significant sexual dimorphism in size. Males have larger tusks, larynx used for alarm, territorial, mating calls.

Habitat and habits: Inhabits desert mountains, rocky terrains/outcrops. Rupicolous; uses crevices for shelter. Herbivorous; feeds on acacia leaves, seeds; occasionally insects, small reptiles. Switches seasonally between grazing, browsing. Does not need to drink water. Diurnal, but primarily crepuscular, with early morning peaks; can also be active during moonlit nights. Sometimes forms colonies (up to 80 individuals) including related females, one territorial male, juveniles; males disperse. Breeding season varies; gestation lasts 6–8 months, 1–6 young per litter.
Abundance: Common.
Conservation status: Global – LC; Regional – LC.

Cape Hare

Lepus capensis (Linnaeus, 1758)



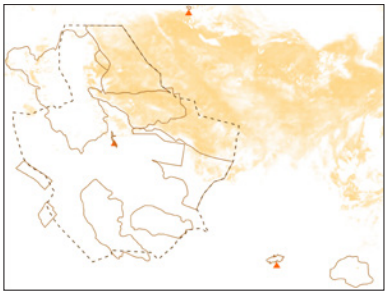
Global distribution: Africa, Middle East, Arabian Peninsula; widespread across Arabian Peninsula.
Distribution in AlUla: Observed between 650 and 1,420 m a.s.l., can be found in AlGharameel, Harrat AlZabin, Harrat Khaybar and Wadi Nakhlah.
Measurements: BW: 1.7–2.5 kg; TBL: 32.9–62 cm; TL: 3–9 cm; HFL: 7.3–14.1 cm; EL: 6.9–13.6 cm; DF: I 2/1, C 0/0, P 3/2, ML 3/3.
Identification: Small-sized hare. Fur silvery grey, black-grizzled; underparts white; nuchal patch brownish pink; collar buffy white. Fur colour varies regionally. Head profile angular. Eyes prominent, white-ringed. Ears long, black-tipped. Hind limbs pale rufous; soles with long hair. Tail short, fluffy, black above, white below. There is no similar species in the region, and it is unlikely to be mistaken for any other mammal.

Habitat and habits: Inhabits various open environments. Selects semideserts, grasslands, scrublands, gravel plains. Found in areas altered by bush clearing, overgrazing. In Arabian Peninsula, selects shrubs for summer shelter. Dens in short, self-excavated burrows beneath shrubs, or occupies existing ones. Herbivorous; grazes on grasses, succulent plants, acacia shrubs, occasionally fungi. Adapted to arid conditions; does not need to drink water. Primarily nocturnal. Solitary or forms small groups. Known to relocate to sprouting grasses in burned areas, overgrazed pastures. Home range 0.11–0.3 km², often overlapping. Breeds year-round, mainly in winter; gestation lasts 42 days, 1–6 young per litter.
Abundance: Abundant.
Conservation status: Global – LC; Regional – NT (VU A2).

Rock Hyrax
Procavia capensis

Cape Hare
Lepus capensis

Black-tailed Garden Dormouse
Eliomys melanurus (Wagner, 1839)



Global distribution: NE Africa, Arabian Peninsula, Levant to Syria and Iraq. Probably widespread in Arabian Peninsula, but with scattered distribution.
Distribution in AlUla: Observed between 770 and 1,160 m a.s.l., can be found in AlGharameel and Sharaan.
Measurements: BW: 38–63 g; TBL: 222–270 mm; TL: 104–120 mm; HFL: 23–29 mm; EL: 24–31 mm; DF: I 1/1, C 0/0, P 1/1, ML 3/3.
Identification: Medium-sized rodent. Fur grey-brown, soft, rather long; underparts white; demarcation line distinct. Face with distinctive black mask; muzzle pale, long. Ears large, oval-shaped, sparsely haired. Hind feet white; soles hairless. Tail long, entirely bushy. No significant sexual dimorphism. There is no similar species in the region, and it is unlikely to be mistaken for any other rodent.

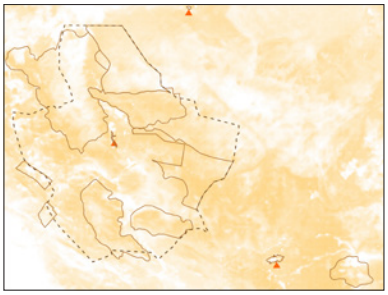
Habitat and habits: Known to be arboreal, but adapted to various treeless habitats. Inhabits desert lowlands, rocky areas, sandstone outcrops, limestone cliffs, mountains. In Saudi Arabia, occupies steppe deserts to juniper forests in areas snow-covered in winter. Reported from gardens, along stone walls in oases, ruins, buildings. Omnivorous: feeds on insects, centipedes, snails, small vertebrates. May enter torpor in cold weather. Nocturnal. Wide range of vocalisations. Solitary; populations concentrated in suitable habitats. Breeding season January-May; gestation lasts 22 days, 2–9 young per litter.
Abundance: Scarce.
Conservation status: Global – LC; Regional – LC.

Arabian Jerboa
Jaculus loftusi (Blanford, 1875)

Global distribution: Across Arabian Peninsula up to SW Iran.
Distribution in AlUla: Observed between 590 and 1,270 m a.s.l., can be found in AlGharameel, Sharaan and Wadi Nakhlah.
Measurements: BW: 112–175 g; TBL: 244–320 mm; TL: 143–175 mm; HFL: 47–56 mm; EL: 16–26 mm; DF: I 1/1, C 0/0, P 0/0, ML 3/3.
Identification: Medium-sized rodent; bipedal, kangaroo-like. Body shape reminiscent of gerbils, but hind limbs extremely long. Fur sandy to pale orange; flanks, underparts stark white. Eyes very large. Ears large, rounded at tip. Soles densely haired. Tail long, with prominent white-tipped tuft with black subterminal band. Females slightly larger. There is no similar species in the region, and it is unlikely to be mistaken for any other rodent.

Habitat and habits: Inhabits sandy, arid open habitats, with sparse vegetation. Occurs in sandy, sandy-gravel, stony deserts. Primarily feeds on seeds, green plant parts. Does not drink water. Nocturnal; activity diminishes in peak summer; spends daytime in burrows, which are simple in stony substrates, complex in sandy ones. Solitary. Breeding season February–November; gestation lasts 25 days, 2–7 young per litter.
Abundance: Scarce.
Conservation status: Global – NE; Regional – NE (LC under *J. jaculus*).

Arabian Spiny Mouse
Acomys dimidiatus (Cretzschmar, 1826)

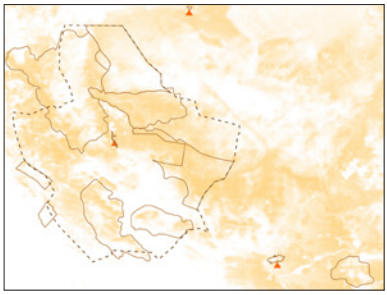


Global distribution: From Sinai through Arabian Peninsula to S Pakistan. Widespread in Saudi Arabia.
Distribution in AlUla: Observed between 440 and 1,790 m a.s.l., can be found in all conservation areas except Tayma.
Measurements: BW: 30–45 g; TBL: 155–247 mm; TL: 72–138 mm; HFL: 16–21 mm; EL: 15–24 mm; DF: I 1/1, C 0/0, P 0/0, ML 3/3.
Identification: Small-sized rodent, mouse-like; back covered with spiny hairs. Fur grey to light brown; underparts white; demarcation line sharp. Eyes relatively large; suborbital white spot. Ears pigmented, virtually hairless; white basal, postauricular patches. Limbs short; hind feet light-coloured; soles hairless. Tail longer than body, bicoloured, virtually hairless, scaled. Similar species: Golden Spiny Mouse (*A. russatus*), but nocturnal, spiny cover less extensive, tail relatively longer.

Habitat and habits: Inhabits mainly rocky areas; absent from open deserts. In Saudi Arabia, recorded in mountains (up to 1900 m a.s.l.), scrublands, semideserts. Dens in crevices amongst rock boulders. Generalist omnivore; feeds on seeds, plant matter, insects. Adapted to both xeric and mesic conditions. Nocturnal. Sometimes forms colonies. Cooperative breeding observed. Breeding season typically spring-autumn, but related to rainfall, temperature; can be year-round with favourable conditions; gestation lasts 36–40 days, 2–5 young per litter.
Abundance: Abundant.
Conservation status: Global – LC; Regional – LC.

Golden Spiny Mouse

Acomys russatus (Wagner, 1840)



Global distribution: N Africa, Middle East, Arabian Peninsula; occurs in Egypt, Sinai, Jordan, Palestine, Saudi Arabia and N Yemen.
Distribution in AlUla: Observed between 340 and 1,740 m a.s.l., can be found in all conservation areas except Tayma.
Measurements: BW: 40–77 g; TBL: 115–248 mm; TL: 57–70 mm; HFL: 15–19.5 mm; EL: 11.8–20.3 mm; DF: I 1/1, C 0/0, P 0/0, ML 3/3.
Identification: Small-sized rodent, mouse-like; body shape rounded, with compact build; back covered with spiny hairs. Fur light golden brown; underparts white. Eyes with suborbital white spot. Ears small, black; pale fur, white patch behind. Hind feet dark; soles hairless. Tail shorter than body, with black scales, silvery bristles. Two morphs are known: light golden brown, dark brown (melanistic). Similar species: Arabian Spiny Mouse (*A. dimidiatus*), but diurnal, spiny cover more extensive, tail relatively shorter.

Habitat and habits: Inhabits rocky landscapes, from desert lowlands to mountains; dens in crevices amongst rock boulders. In Saudi Arabia, also found in black lava fields (*harrats*). Omnivorous: feeds on seeds, plants (including halophytic genera), insects. Requires moist diet to balance intense evaporative cooling. Diurnal/crepuscular where co-occurring with *A. dimidiatus*; where not so, nocturnal. Can form colonies; territorial. Breeds year-round. Gestation lasts 5–6 weeks, 1–4 young per litter. Notably, females build nests for offspring.
Abundance: Abundant.
Conservation status: Global – LC; Regional – LC.

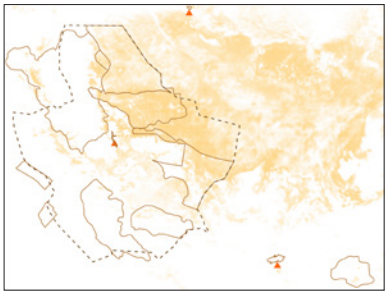
Black-tailed Garden Dormouse
Eliomys melanurus

Arabian Jerboa
Jaculus loftusi

Arabian Spiny Mouse
Acomys dimidiatus

Golden Spiny Mouse
Acomys russatus

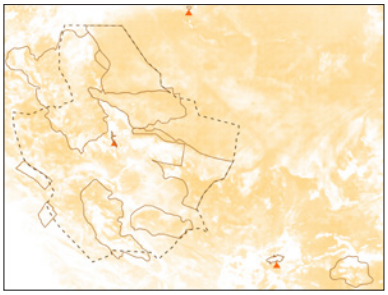
Cheesman's Gerbil
Gerbillus cheesmani (Thomas, 1919)



Global distribution: Arabian Peninsula to SW Iran. Presence confirmed in Iraq, Iran, Syria (marginally), Jordan, Oman, Qatar, Saudi Arabia, Yemen and UAE.
Distribution in AlUla: Observed between 410 and 1,270 m a.s.l., can be found in AlGharameel, Sharaan, and Wadi Nakhlah.
Measurements: BW: 10–63 g; TBL: 172–235 mm; TL: 94–146 mm; HFL: 24–33 mm; EL: 9–14 mm; DF: I 1/1, C 0/0, P 0/0, ML 3/3.
Identification: Medium-sized gerbil; slender, with graceful build. Fur sandy buff; underparts cream to white; demarcation line sharp. Eyes with white patches above. Ears large, with white patches behind. Hind feet elongated; soles densely white-haired. Tail longer than body, with white/greyish tuft. Males slightly larger; no marked sexual dimorphism in colour. Similar species: Balochistan Gerbil (*G. nanus*), but fur much darker.

Habitat and habits: In Middle East deserts, inhabits sandy soils, dunes, mud flats, up to 1240 m a.s.l. In Saudi Arabia, found in association with *Haloxylon*, *Calligonum*, *Artemisia* plants. Dens in complex burrow systems with multiple entrances, usually near shrubs for cover. Primarily granivorous; supplements with grasses, insects; food storage in burrows observed. Adapted to arid conditions. Nocturnal. Solitary. Breeds year-round; gestation lasts 20–22 days, 1–8 young per litter.
Abundance: Common.
Conservation status: Global – LC; Regional – LC.

Wagner's Gerbil
Gerbillus dasyurus (Wagner, 1842)

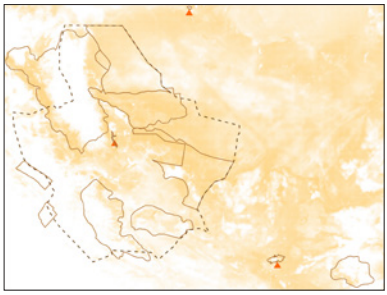


Global distribution: Restricted to Arabian Peninsula, Sinai, probably S Turkey. Populations reported in Bahrain, Palestine, Jordan, Lebanon and Syria.
Distribution in AlUla: Observed between 440 and 1,720 m a.s.l., can be found in all conservation areas except AlUla Oasis, Old Khaybar and Tayma.
Measurements: BW: 15–35 g; TBL: 162–227 mm; TL: 88–126 mm; HFL: 20–26.5 mm; EL: 10–15.5 mm; DF: I 1/1, C 0/0, P 0/0, ML 3/3.
Identification: Medium-sized gerbil, with slender build. Fur pale grey-yellow with fine black speckles; underparts pure white; distinct supraorbital, auricular white patches; black eyebrow marking. Pelage dense, long; 'gloss' on back. Hind feet soles darkly pigmented, hairless. Tail long, bicoloured, well covered with hair, terminating with pencil-like tuft. Males smaller but heavier. Similar species: Balochistan Gerbil (*G. nanus*), but tail, ears slightly longer; Cheesman's Gerbil (*G. cheesmani*), but soles hairless.

Habitat and habits: Inhabits rocky terrains. In Saudi Arabia, occurs in limestone escarpments with *Rhanterium epapposum*, other herbs, grasses, up to 2,000 m a.s.l. Dens among rocks, or in simple, chambered burrows under bushes, closed during daytime. Feeds primarily on seeds of annual herbs, succulent plants; occasionally insects. Strictly nocturnal. Mainly solitary. Known social behaviours: territory marking via mid-ventral glands, 'ceremonial' digging, drumming with hind feet. Home range extensive. Reproductive season February–October; gestation 18–26 days, 2–7 young per litter.
Abundance: Abundant.
Conservation status: Global – LC; Regional – LC.

Balochistan Gerbil

Gerbillus nanus (É. Geoffroy, 1803)



Global distribution: Across N Africa, from Sinai to Pakistan and NW India, including Arabian Peninsula.
Distribution in AlUla: Observed between 410 and 1,640 m a.s.l., can be found in AlGharameel, Harrat Khaybar, Harrat Uwayrid, Jabal Nahar, Old Khaybar and Wadi Nakhlah.
Measurements: TBL: 140–235 mm; TL: 80–145 mm; HFL: 18.5–28 mm; EL: 7–14.5 mm; DF: I 1/1, C 0/0, P 0/0, ML 3/3.
Identification: Small- to medium-sized gerbil. Fur distinctive pale sandy to greyish; underparts, limbs pure white; demarcation line sharp; rump with a prominent white patch. Pelage soft. Eyes, ears distinctive, rather large; ear tip pigmented. Hind limbs long; hind feet slender, with hairless, unpigmented soles. Tail bushy, slender; ends with distinct black tuft. Pelage varies seasonally; summer coat shorter, paler. Sexual dimorphism subtle, males slightly larger. Similar species: Wagner's Gerbil (*G. dasyurus*), but occupies different habitats; Cheesman's Gerbil (*G. cheesmani*), but fur much lighter.

Habitat and habits: Inhabits arid, semiarid regions, predominantly sand, saline flats, semideserts; absent from true sandy deserts. In Arabian Peninsula, selects rocky deserts with sparse vegetation. Dens in intricate burrow systems. Flexible foraging strategy; feeds primarily on seeds, leaves; consumes insects depending on season; can cover long distances in search of food. Effective water-saving physiological mechanisms; adapted to extreme aridity. Nocturnal; activity noted post-sunset. Solitary outside mating season, with occasional communal foraging. Breeding season varies; gestation lasts 20 days, 1–6 young per litter.
Abundance: Common.
Conservation status: Global – LC; Regional – LC.

Large Aden Gerbil

Gerbillus poecilops Yerbury & Thomas, 1895

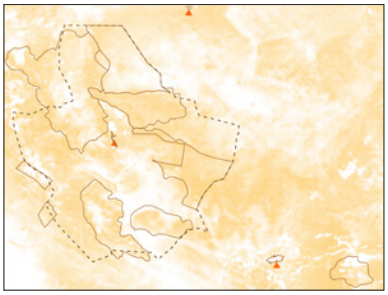
Global distribution: Restricted to coastal mountain ranges of Red Sea and Gulf of Aden; endemic to SW Saudi Arabia and Yemen.
Distribution in AlUla: Observed at 1,220 m a.s.l., can be found in Wadi Nakhlah.
Measurements: TBL: 150–222 mm; TL: 72–115 mm; HFL: 19–24 mm; EL: 8–12 mm; DF: I 1/1, C 0/0, P 0/0, ML 3/3.
Identification: Robust gerbil. Fur fawn to grey; underparts pure white; demarcation line sharp; distinctive facial markings include conspicuous white supraorbital spots, greyish-black cheek patches, blackish stripe on nose. Pelage soft, dense. Eyes large, black-ringed. Ears small compared to eyes, with large hairless patches beside. Forefeet bear rudimentary thumb; soles hairless. Tail short, broad, bicoloured, lacking tuft; sparsely covered in short hairs.

Habitat and habits: Inhabits sandy areas near human settlements, cultivated fields. In Saudi Arabia, found in areas with cotton, sorghum cultivations. Feeds on vegetable matter. Less adapted to arid regions compared to other congeners. Likely nocturnal. Breeding season spring/summer.
Abundance: Rare.
Conservation status: Global – LC; Regional – LC.


Cheesman's Gerbil
Gerbillus cheesmani
Wagner's Gerbil
Gerbillus dasyurus
Balochistan Gerbil
Gerbillus nanus
Large Aden Gerbil
Gerbillus poecilops

Sundevall's Jird

Meriones crassus (Sundevall, 1842)

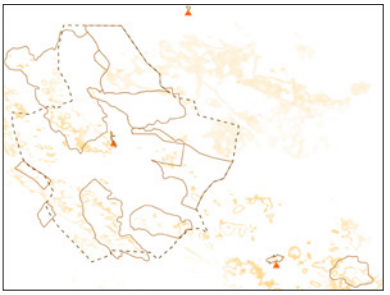


Global distribution: Across N Africa, from Morocco to Egypt, extending southwards to Sudan; Asia, across Arabian Peninsula to Turkey and W Pakistan. Not found in Yemen.
Distribution in AlUla: Observed between 550 and 1,740 m a.s.l., can be found in AlGharameel, Harrat AlZabin, Harrat Khaybar, Jabal Shayhoub and Wadi Nakhlah.
Measurements: BW: 55–158 g; TBL: 205–290 mm; TL: 98–145 mm; HFL: 25–35 mm; EL: 12–19 mm; DF: I 1/1, C 0/0, P 0/0, ML 3/3.
Identification: Large-sized jird. Fur sandy-coloured; underparts white; demarcation indistinct. Pelage long, silky. Eyes with white patch above. Ears unpigmented, sparsely haired. Soles partially haired; claws ivory-white. Tail bicoloured, with short hairs, conspicuous black tuft. Seasonal pelage variation reported. No significant sexual dimorphism in size.

Habitat and habits: Inhabit areas with sparse vegetation: rocky *wadis*, palm/acacia groves, sandy deserts, *hammada* habitats (up to 1500 m a.s.l.). Infrequent in mountainous regions, Mediterranean climates. Dens in complex burrow systems; also excavated into hard substrates. Feeds primarily on plants, seeds; occasionally insects. Covers up to 10 km to forage. Adapted to water scarcity. Nocturnal; dusk, diurnal activities reported. Social structure flexible: both solitary, gregarious behaviours reported. Home range extensive. Breeding season November–June; gestation lasts up to 31 days, 1–5 young per litter.
Abundance: Scarce.
Conservation status: Global – LC; Regional – LC.

House Mouse

Mus musculus (Linnaeus, 1758)

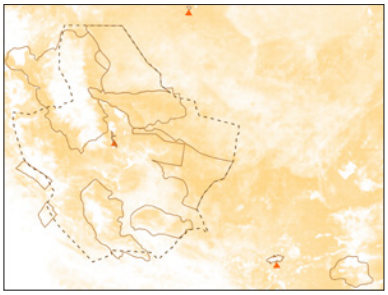


Global distribution: Worldwide, excluding Antarctica. Native from Mediterranean region to China. Widespread due to human influence.
Distribution in AlUla: Observed between 700 and 770 m a.s.l., can be found in AlUla Oasis and Old Khaybar.
Measurements: BW: 12-39 g; TBL: 111-181 mm; TL: 54–94 mm; HFL: 13.8–20 mm; EL: 9–15 mm; DF: I 1/1, C 0/0, P 0/0, ML 3/3.
Identification: Small-sized rodent, with slender body. Fur ochraceous to brown, highly variable (related to habitat type); underparts whitish to greyish. Snout pointed. Facial spots light-coloured, indistinct compared to spiny mice. Ears short, with rounded edges, mostly hairless. Limbs greyish, short; digits small, unpigmented, hairless. Tail bicoloured, longer than body, mostly hairless, annulated. Males slightly larger, more robust. Similar species: spiny mice (*A. dimidiatus*, *A. russatus*), but smaller, white underparts less distinct, back not covered in spines.

Habitat and habits: Inhabits mainly regions close to human settlements, but occurs in disparate habitats. In Saudi Arabia, found in urban to semi-urban areas. Absent from true deserts. Can excavate shallow burrows. Omnivorous; feeds on seeds, grains, insects, other invertebrates. Not well adapted to arid conditions. Primarily nocturnal; diurnal activity reported. Forms commensal or feral populations. Solitary or forms groups. Apparently subordinate to *A. dimidiatus*. Breeds year-round under favourable conditions; gestation lasts 19–21 days, 3–12 young per litter.
Abundance: Scarce.
Conservation status: Global – LC; Regional – NA.

Fat Sand Rat

Psammomys obesus (Cretzschmar, 1828)



Global distribution: Across N Africa: from Mauritania to Egypt and Sudan. Occurs in Syria, Palestine, Jordan and Saudi Arabia.
Distribution in AlUla: Observed between 610 and 1,270 m a.s.l., can be found in Harrat AlZabin, Harrat Uwayrid, Jabal Shayhoub, Sharaan and Wadi Nakhlah.
Measurements: BW: 82–237 g; TBL: 233–435 mm; TL: 95–152 mm; HFL: 30–40 mm; EL: 13.5–18 mm; DF: I 1/1, C 0/0, P 0/0, ML 3/3.
Identification: Large-sized jird-like rodent, with robust build. Fur distinctive, ochre to tawny brown with black speckles; underparts paler. Pelage short. Head bulky. Ears short, rounded, covered with fine whitish hairs. Limbs sturdy; hind feet with robust, black claws; soles partially haired. Tail moderately long, thick, densely haired, distinctively black-tipped. Males larger. There is no similar species in the region, and it is unlikely to be mistaken for any other rodent.

Habitat and habits: Ecologically unique. Occupies habitats dominated by saltbushes: halophytic steppes, *wadis*, semideserts, deserts, occasionally gravel plains. Across Arabian Peninsula, prevalent in rocky, grassland areas. Dens in intricate but shallow burrow systems in open areas with multiple openings close to saltbushes. Feeds strictly on succulent plant parts (largely leaves) of saltbushes. Efficient water and salt recycling mechanisms. Prevalently diurnal; nocturnalism reported. Territorial. Solitary, but forms colonies. Rather sedentary (excluding juveniles); home range limited; covers short distances for foraging; does not cache food. When alert, adopts a sitting position similar to prairie dogs. Intraspecific communication via vocalisations, foot-drumming. Breeding season December–April; gestation lasts 24 days, 2–8 young per litter.
Abundance: Common.
Conservation status: Global – LC; Regional – LC.

Bushy-tailed Jird
Sekeetamys calurus (Thomas, 1892)

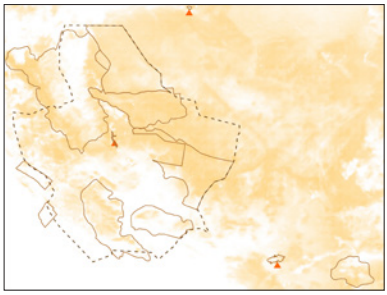
Global distribution: Egypt to Levant and Arabian Peninsula. Presence reported in C Saudi Arabia and S Oman.
Distribution in AlUla: Observed between 440 and 1,760 m a.s.l., can be found in all conservation areas except AlUla Oasis, Jabal Shayhoub, Old Khaybar, and Tayma.
Measurements: BW: 26–50 g; TBL: 227–274 mm; TL: 112–148 mm; HFL: 28.3–33 mm; EL: 17–19 mm; DF: I 1/1, C 0/0, P 0/0, ML 3/3.
Identification: Readily recognisable by long tail, bushy across its full length, with distinctive white tip (not always present); base is yellow-brown; tail held suspended on ground during locomotion like squirrels. Small-sized jird. Fur sandy buff with black speckles; underparts whitish. Pelage long, dense. Vibrissae long. Eyes large. Ears large, darkly pigmented, slightly elongated. Hind feet elongated, narrow; soles pigmented, hairless; claws cream-coloured. No significant sexual dimorphism. Fur colour varies geographically. There is no similar species in the region, and it is unlikely to be mistaken for any other rodent.

Habitat and habits: Inhabits arid, rugged terrains, rocky mountain sides, especially steep slopes with boulders, up to 600 m a.s.l.; apparently absent from sandy areas. Does not dig burrows; uses natural rock formations, crevices for shelter. Adept climber. Omnivorous: feeds on various plants; insects can represent a high proportion of diet. Feeding strategy peculiar compared to other arid-adapted granivorous rodents. Primarily nocturnal. Solitary or forms small groups. Males' home range more extensive. Breeding season February-March (possibly); gestation lasts 21–24 days, 1–5 young per litter.
Abundance: Common.
Conservation status: Global – LC; Regional – LC.

Lesser White-toothed Shrew
Crocidura suaveolens (Pallas, 1811)

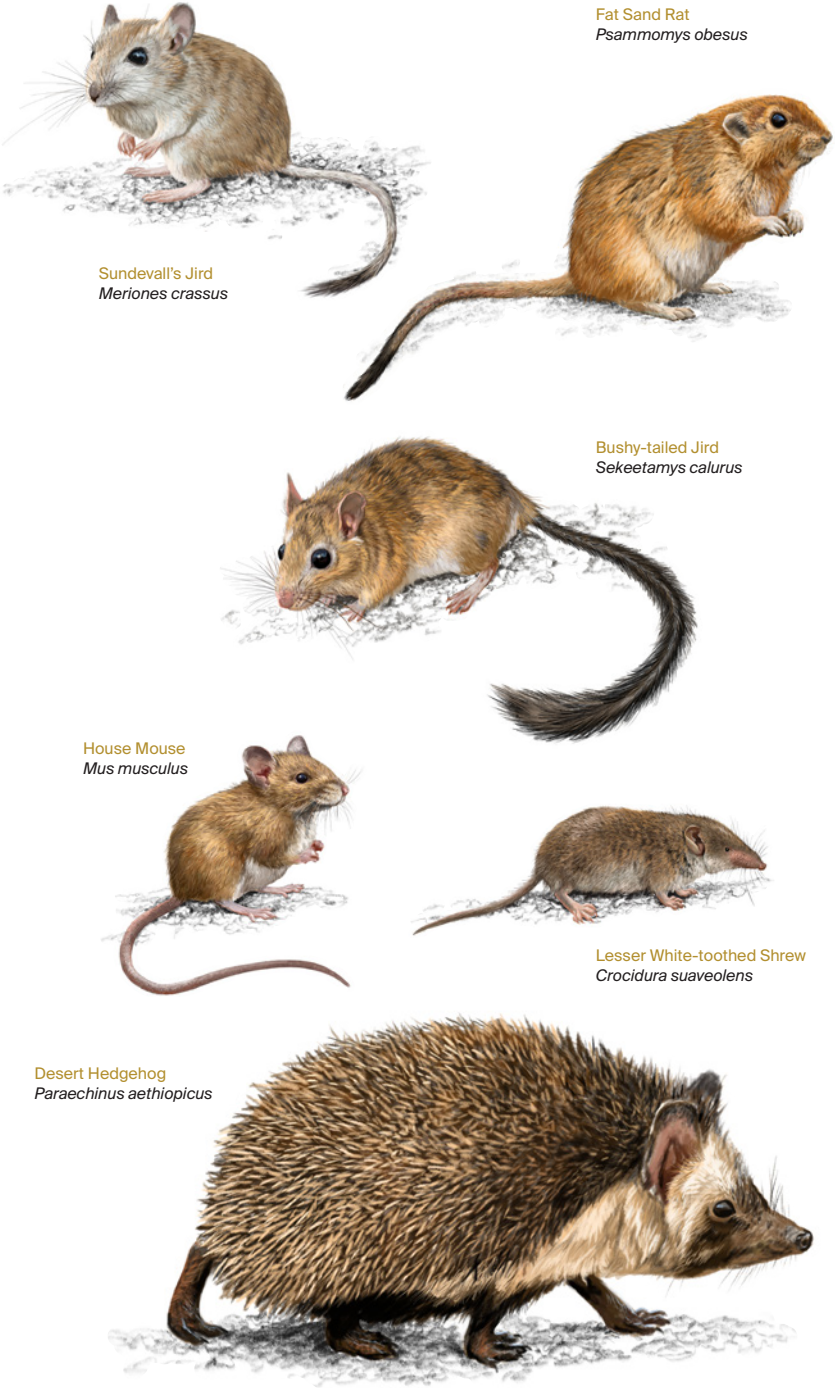
Global distribution: Across Palaearctic: from E Europe to Mongolia. Presence reported in Arabian Peninsula: Iraq, Jordan, Sinai, Saudi Arabia and Yemen.
Distribution in AlUla: Observed at 1,040 m a.s.l., can be found in Harrat Uwayrid.
Measurements: BW: 4.5–9.4 g; TBL: 92–126 mm; TL: 35–53 mm; HFL: 10.3–13.6 mm; EL: 4–9.8 mm; DF: I 3/1, C 1/1, P 1/1, ML 3/3.
Identification: Medium-sized shrew, with light build. Fur greyish brown to light grey; underparts light grey to white. Tail often bicoloured, sometimes uniform; reaches almost half of body length; bristles throughout full length. Teeth white-tipped. Similar species: White-toothed Shrew (*C. russula*), but size smaller; different *Crocidura* species are often difficult to distinguish morphologically.
Habitat and habits: Inhabits in deserts, steppes, forests. Selects mesic habitats with thick vegetation, nearby human settlements. In SW Asia, reported from habitats with long dry grasses; thick vegetation along streams, river edges, vegetation channels; around houses, in forested areas. Forms nests under various shelters; nests often found in proximity to water, in dry grass or among plant litter. Feeds on insects; plant material secondarily. Can dig insects out of soil; leaps to catch prey on vegetation; reported storing food. Primarily nocturnal. Breeding season varies by region; gestation lasts 24–32 days, 1–10 young per litter.
Abundance: Rare.
Conservation status: Global – LC; Regional – LC.

Desert Hedgehog
Paraechinus aethiopicus (Ehrenberg, 1833)



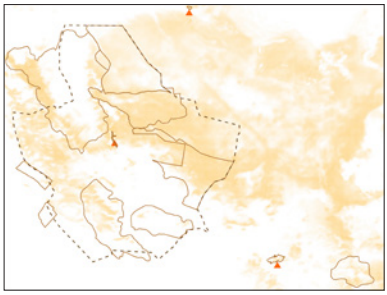
Global distribution: From W Sahara to Arabian Peninsula, including Saudi Arabia. Insular populations in Djerba (Tunisia), Bahrain and Tonb (Iran).
Distribution in AlUla: Observed between 240 and 1,790 m a.s.l., can be found in all conservation areas except Jabal Al Ward and Jabal Nahar.
Measurements: BW: 285–700 g; TBL: 147–249 mm; TL: 14–35 mm; HFL: 26–35 mm; EL: 32–48 mm; DF: I 3/2, C 1/1, P 3/2, ML 3/3.
Identification: Medium-sized hedgehog. Dorsal spines pale brown with dark tips, banded pattern; underparts non-spiny, whitish, with dark patches (geographically variable). Forehead has white, broad band, reaching up to cheeks. Face has a dark mask, extending from muzzle to below cheeks. Snout not as pointed as a long-eared hedgehog (*Hemiechinus auritus*). Ears large, exceeding spine length. Tail very short. Spines constitute primary defence mechanism; rolls into ball when threatened. Apparently, there is no similar species in the region, and it is unlikely to be mistaken for any other hedgehog.

Habitat and habits: Inhabits deserts, semideserts, rocky *wadis*, coastal plains; thrives in oases, vegetated *wadis*. In Arabian Peninsula, absent from high altitudes. Dens in self-excavated burrows, provided with multiple openings. Primarily insectivorous; feeds on insects, grubs, scorpions, small vertebrates, eggs, fruit, roots. Enters torpor in cold weather; less visible during winter in Saudi Arabia. Adapted to hyper-arid conditions. Nocturnal; possibly crepuscular. Solitary, territorial. Sedentary; home range limited. Breeding season February-June; gestation lasts 34–46 days, 2–7 young per litter.
Abundance: Abundant.
Conservation status: Global – LC; Regional – LC.


Fat Sand Rat
Psammomys obesus
Sundevall's Jird
Meriones crassus
Bushy-tailed Jird
Sekeetamys calurus
House Mouse
Mus musculus
Lesser White-toothed Shrew
Crocidura suaveolens
Desert Hedgehog
Paraechinus aethiopicus

Egyptian Rousette

Rousettus aegyptiacus (E. Geoffroy, 1810)

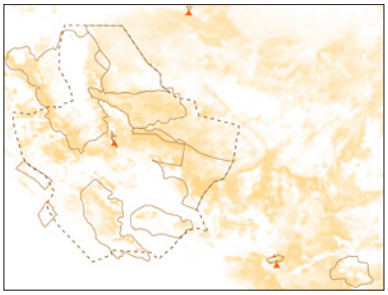


Global distribution: Widespread in Sub-Saharan and N Africa; across Arabian Peninsula to Turkey, Cyprus, Iran, Pakistan and NW India. Presence reported in islands of Gulf of Guinea.
Distribution in AlUla: Observed between 660 and 1,300 m a.s.l., can be found in AlUla Oasis, Harrat Uwayrid, Jabal Al Ward, Old Khaybar and Tayma.
Measurements: BW: 80–171 g; TL: 5–19 mm (M), 7–22 mm (F); FA: 87–99 mm (M), 81–95 mm (F); EL: 18–25 mm (M), 18–24 mm (F); DF: I 2/2, C 1/1, P 3/3, ML 2/3.
Identification: Small- to medium-sized fruit bat, with robust build. Fur dark sepia brown to greyish-brown; on neck, paler, sparser; underparts paler. Head large. Eyes large. Snout long, dog-like. Ears brown, hairless, with rounded tips. Wing membrane is blackish-brown; wingspan up to 60 cm. Tail extends beyond uropatagium. Males have paler, stiffer hairs on throat.

Habitat and habits: Occupies various habitats with fruiting trees, caves (up to 4000 m a.s.l.). In Saudi Arabia, very abundant in urban areas, oases, palm gardens, fig/grape plantations; large colonies observed. Roosts in caves, lava tunnels; co-roosts with other bat species. Feeds on soft fruits, nectar, pollen; uses trees as feeding perches. Covers large distances to forage; flight slow, poorly manoeuvrable; can hover briefly; proficient climber. Huddles to thermoregulate. Nocturnal. Forms mixed-sex colonies. Breeding season varies based on latitude; gestation lasts 3.5–4 months, 1–2 young per litter.
Abundance: Scarce.
Conservation status: Global – LC; Regional – LC.

Geoffroy's Trident Leaf-nosed Bat

Asellia tridens (E. Geoffroy, 1813)

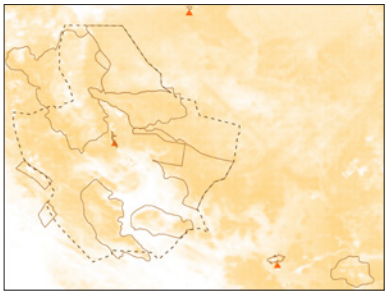


Global distribution: N Africa, Middle East to Afghanistan and Pakistan. Widely distributed across Arabian Peninsula. Reaches southward Ethiopia and Somalia.
Distribution in AlUla: Observed between 700 and 1,610 m a.s.l., can be found in Harrat AlZabin, Harrat Khaybar, Old Khaybar, Sharaan and Wadi Nakhlah.
Measurements: BW: 6–13 g; TL: 16–29 mm; FA: 43–56 mm; EL: 14–22 mm; DF: I 1/2, C 1/1, P 1/2, ML 3/3.
Identification: Small-sized bat; largest in genus. Fur beige or pale brownish-grey; underparts paler. Orange-brownish, intermediate variants reported. Noseleaf distinctive: three-cusped, with central cusp pointed. Ears rather large, long; tragus absent. Tail extends beyond uropatagium. Males larger (females larger in some regions).

Habitat and habits: Inhabits desert, semidesert (up to 2000 m a.s.l.). Selects oases, dry riverbeds. Roosts in caves, cliff crevices, buildings, mines. Feeds on large insects (beetles, moths, flies), scorpions. Flight low, agile, manoeuvrable, butterfly-like; forages by slow-hawking, ground-gleaning. Adapted to arid conditions; can hibernate. Unusually light-tolerant. Mainly nocturnal. Forms colonies, often large (up to thousands); sexual segregation varies. Migratory behaviour noted in some regions during winter. Seasonal breeder; gestation lasts 9–10 weeks, 1 young per litter.
Abundance: Scarce.
Conservation status: Global – LC; Regional – LC.

Egyptian Free-tailed Bat

Tadarida aegyptiaca (E. Geoffroy, 1818)

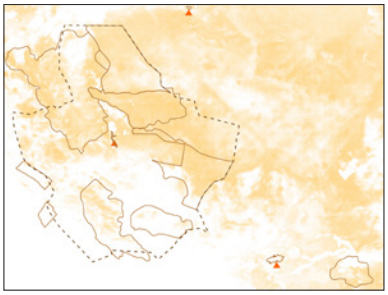


Global distribution: Africa, Arabian Peninsula, India, Sri Lanka and Bangladesh.
Distribution in AlUla: Observed between 640 and 1,800 m a.s.l., can be found in all conservation areas except AlUla Oasis.
Measurements: BW: 9–22 g; TL: 30–50 mm; FA: 42–52 mm; EL: 13–22 mm; DF: I 1/2, C 1/1, P 2/2, ML 3/3.
Identification: Small-sized bat. Fur grey, greyish-brown, reddish-brown, or blackish-brown; underparts slightly paler; flank stripe paler to white; limbs with ventral aspect hairless, whitish; fur with 'frosted' appearance. Ears brown to black, forward-facing, with inner margins forming a V-shaped valley on snout; tragus large. Gular gland in both sexes. Wing membrane brown to blackish, semi-translucent. Hind feet soles with elevated pad. Tail extends beyond uropatagium. No significant sexual dimorphism; males slightly smaller.

Habitat and habits: Inhabits arid, semiarid environments; associated with rock crevices, cliffs, man-made structures. Roosts in caves, trees, buildings; sometimes under bark or in hollow tree trunks; co-roosts with other bat species. Feeds on beetles, moths, wasps and other insects. Flight high, slow; climbs nimbly; forages by fast-hawking, also over water. Adapted to arid conditions, but needs to drink water. Nocturnal. Solitary or forms colonies (up to thousands). Breeding season May–August; gestation lasts 4 months, 1 young per litter.
Abundance: Abundant.
Conservation status: Global – LC; Regional – DD.

European Free-tailed Bat

Tadarida teniotis (Rafinesque, 1814)

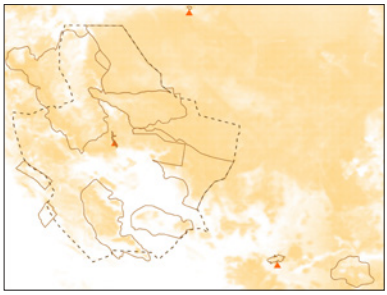


Global distribution: Mediterranean Europe, N Africa, Middle East, C Asia and India. Present in Jordan, Palestine, NW Saudi Arabia and Iraq. Presence recorded in Madeira and Canary Islands.
Distribution in AlUla: Observed between 490 and 1,570 m a.s.l., can be found in AlGharameel, AlUla Oasis, Harrat Uwayrid, Jabal Al Ward, Jabal Nahar, Sharaan, and Wadi Nakhlah.
Measurements: BW: 20–40 g; TL: 43–55 mm; FA: 58–64 mm; EL: 25–32 mm; DF: I 1/3, C 1/1, P 2/2, ML 3/3.
Identification: Medium-sized bat. Fur ashy-grey to brownish-grey; underparts paler; limbs with ventral aspect hairless, blackish. Upper lip with distinctive wrinkles. Ears large, blackish; form V-shaped valley on forehead. Wing membrane blackish. Hind feet soles with elevated pad. Tail extends beyond uropatagium.

Habitat and habits: Inhabits semideserts, shrublands (up to 3100 m a.s.l.); selects rocky habitats. Roosts in rock crevices, urban structures. Feeds on moths, beetles, neuropterans, hemipterans. Flight high, fast, direct, agile, poorly manoeuvrable; forages by fast-hawking within 5–15 km radius. Emerges well after sunset. Sedentary; partially migratory in North Africa. Solitary or forms colonies; maternity colonies reported. Breeding season is May–October; 1 young per litter.
Abundance: Abundant.
Conservation status: Global – LC; Regional – LC.

Naked-rumped Tomb Bat

Taphozous nudiventris (Cretzschmar, 1830)



Global distribution: Africa (N, C, E), Middle East, Arabian Peninsula, Indian subcontinent and Myanmar. Presence reported in Saudi Arabia, Oman, Yemen and UAE.
Distribution in AlUla: Observed between 700 and 1,560 m a.s.l., can be found in AlGharameel, Harrat Uwayrid, Jabal Al Ward, Jabal Shayhoub, Old Khaybar, Tayma, and Wadi Nakhlah.
Measurements: BW: 30–35 g; TL: 19–41 mm; FA: 64–83 mm; EL: 18–27 mm; DF: I 1/2, C 1/1, P 2/2, ML 3/3.
Identification: Medium-sized bat. Fur greyish-brown, dark brown, or sepia; underparts paler. Rump, flanks, abdomen, hind limbs hairless, distinctive. Muzzle squared. Eyes conspicuous. Ears subtriangular, backward-facing, with papillae along inner margin; tragus hatchet-shaped. Males have well-developed glandular gular pouch, sternal gland; radio-metacarpal sacs in both sexes. Wing membrane intense dark brown. Tail extends beyond uropatagium. Males slightly larger.

Habitat and habits: Inhabits arid, semiarid habitats, shrublands. Roosts in crevices (cliffs, rocks, caves), ruins, tree hollows. Feeds on beetles, crickets, grasshoppers, cockroaches, moths, winged termites. Flight high, fast, agile, poorly manoeuvrable; forages by fast-hawking. Emerges after sunset. Forms colonies (up to several hundred); maternity colonies during parturition. May hibernate; deposits fat reserves. Rather light-tolerant. Migrates during winter. Breeding season autumn (depending on region); gestation lasts 98 days; 1 young per litter.
Abundance: Common.
Conservation status: Global – LC; Regional – LC.

Egyptian Rousette
Rousettus aegyptiacus

Naked-rumped Tomb Bat
Taphozous nudiventris

Geoffroy's Trident Leaf-nosed Bat
Asellia tridens

Egyptian Free-tailed Bat
Tadarida aegyptiaca

European Free-tailed Bat
Tadarida teniotis

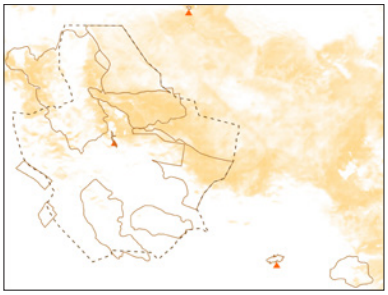
Egyptian Slit-faced Bat

Nycteris thebaica (E. Geoffroy, 1818)

Global distribution: Across Africa: from Egypt and Morocco to S Africa. Recorded in Palestine, Sinai and C Saudi Arabia. Presence reported in Somalia, Kenya, Zanzibar and Pemba Islands.
Distribution in AlUla: Observed between 450 and 1,190 m a.s.l., can be found in Harrat Khaybar, Harrat Uwayrid, Jabal Shayhoub and Sharaan.
Measurements: BW: 6–16 g; TL: 47–58 mm; FA: 40–49 mm; EL: 28–35 mm; DF: I 2/3, C 1/1, P 1/2, ML 3/3.
Identification: Small-sized bat, with slender build. Fur grey to dark brown; orange variant reported; underparts paler, greyish-white to white; fur long, soft. Snout hairless. Noseleaf with lobed slit. Eyes small. Ears long; notable in males. Pyriform (pear-shaped) tragus distinctive. Wing membrane is dark grey to greyish-brown. Tail embedded in uropatagium; tip T-shaped. No significant sexual dimorphism in colour. Females are larger in some populations.

Habitat and habits: Inhabits rocky, riparian, oases areas; absent from deserts. Roosts in caves, mine adits, tree hollows, root cavities; roost switching reported. In Saudi Arabia, found in ruins, well shafts, bungalows. Feeds on various insects (grasshoppers, moths, beetles), scorpions, sun-spiders; rarely vertebrates. Flight low, slow, greatly manoeuvrable (grants access to roosts inaccessible to other bat species), 'erratic'; can hover; forages by slow-hawking, fly-catching, foliage-gleaning, ground-gleaning. Transports prey back to perch. Needs to drink water. Crepuscular to nocturnal. Solitary or forms colonies. Migratory tendencies noted. Breeding season April–June; gestation lasts 2.5–6 months, 1 young per litter.
Abundance: Scarce.
Conservation status: Global – LC; Regional – LC.

Arabian Barbastelle
Barbastella leucomelas (Cretzschmar, 1826)

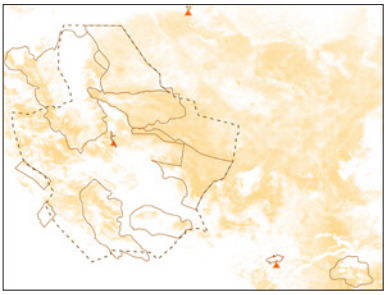


Global distribution: Sinai, Eritrea, Caucasus, N Iran, Afghanistan, Pamirs, India, Nepal, W China and Japan. In Arabian Peninsula, presence reported near Sinai.
Distribution in AlUla: Observed between 840 and 1,280 m a.s.l., can be found in Harrat Uwayrid, Sharaan, and Wadi Nakhlah.
Measurements: BW: 5–9 g; TL: 33.2–51 mm; FA: 37.3–39.5 mm; EL: 18 mm (1); DF: I 2/3, C 1/1, P 2/2, ML 3/3.
Identification: Small-sized bat, long-limbed. Ears broad but short, squarish, forward-projecting, joined across forehead; tragus large, haired. Snout broad, short, with prominent paired haired glandular swellings. Fur blackish to brownish or greyish; often with golden tips conferring silky, 'frosted' appearance; underparts slightly lighter. Muzzle short, broad, surrounded by large glandular mass. Wings pale brown. Tail extends beyond uropatagium by little. No significant sexual dimorphism.

Habitat and habits: Inhabits in deserts, semidesert grasslands, mountains; potentially uses riparian forests. Roosts in caves, mines, tunnels, rock crevices, hollow trees, under bark. Feeds on moths, ants; ambush predator. Flight low, rather fast, fluttering. Adapted to arid environments. Nocturnal; late emergence (possibly twice a night). Typically solitary; maternity colonies reported (up to 10 females). 1–2 young per litter, twins observed.
Abundance: Scarce.
Conservation status: Global – LC; Regional – DD.

Botta's Serotine

Cnephaeus bottae (Peters, 1869)

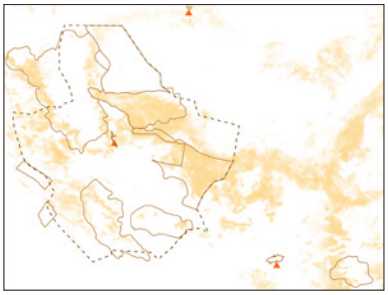


Global distribution: Middle East, including parts of Turkey, Egypt, Palestine, Jordan, Saudi Arabia and Yemen. Presence reported in Iran, Pakistan, Kazakhstan and Mongolia.
Distribution in AlUla: Observed between 1,020 and 1,290 m a.s.l., can be found in Harrat Khaybar, Harrat Uwayrid, Jabal Al Ward, Sharaan and Wadi Nakhlah.
Measurements: BW: 8–9 g; TL: 36–53 mm; FA: 37–52 mm; EL: 14–18 mm; DF: I 2/3, C 1/1, P 1/2, ML 3/3.
Identification: Medium-sized bat. Fur light to dark creamy buff, sometimes with rusty brown tinge; underparts paler; hair base always grey. Wing membrane reddish brown. Eyes inconspicuous. Ears are simple, short but broad, triangular, with rounded tips. Tragus short, narrow. Tail extends beyond uropatagium by little. Sexes similar in fur colour; females slightly larger.

Habitat and habits: Inhabits semideserts, steppes, savannas, cultivated areas, date groves, rocky mountains (up to 2,100m a.s.l.). Absent from true deserts. Selects areas near water bodies. Roosts in rock crevices, buildings, ruins. Feeds on insects: ants, beetles, moths. Flight high, slow, strong; forages by slow-hawking. Crepuscular to nocturnal. Forms small colonies, sometimes solitary. 1–2 young per litter, twins observed.
Abundance: Abundant.
Conservation status: Global – LC; Regional – LC.

Fairy Pipistrelle

Hypsugo ariel (Thomas, 1904)

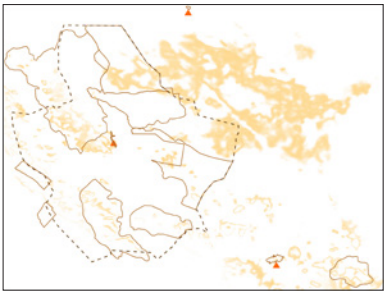


Global distribution: Palestine, Jordan, Palestine, Sudan (NE, SC), W Saudi Arabia, Yemen (including Socotra) and Oman; possibly SE Egypt and Kenya.
Distribution in AlUla: Observed between 820 and 1,290 m a.s.l., can be found in Harrat Khaybar, Jabal Al Ward, Sharaan, Tayma and Wadi Nakhlah.
Measurements: TL: 32–44 mm; FA: 28–34 mm; DF: I 2/3, C 1/1, P 2/2, ML 3/3.
Identification: Small-sized bat, with light build. Fur pale, ranging from pinkish brown or deep olive-buff to off-white. Wing membrane pale brown. Forehead profile markedly concave. Ears short, narrow, with rounded tips. Tragus is inconspicuous, curved inward. Tail embedded in uropatagium or slightly extending beyond.

Habitat and habits: Inhabits rocky areas, deserts, semideserts. In Saudi Arabia, it is often associated with oases, agricultural areas, water bodies. Roosts in crevices during daytime; forages in open areas, near trees, around water. Diet includes beetles, moths, other flying insects. Adapted to arid conditions. Crepuscular to nocturnal. May hibernate in colder periods. Likely solitary or forms small groups. Breeding season possibly around May (some regions); females may give birth twice a year.
Abundance: Abundant.
Conservation Status: Global – DD; Regional – LC.

Geoffroy's Myotis

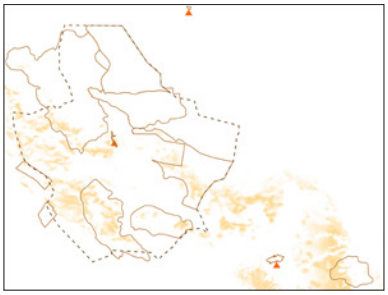
Myotis emarginatus (E. Geoffroy, 1806)



Global distribution: Europe (S, C), N Africa, Middle East and Asia (W, C). Presence reported in NW Arabian Peninsula and Oman.
Distribution in AlUla: Observed between 700 and 1,200 m a.s.l., can be found in Harrat AlZabin, Harrat Uwayrid, Old Khaybar and Tayma.
Measurements: BW: 5.5–15.5 g; TL: 35–45 mm; FA: 36–44 mm; EL: 13.8–17.8 mm; DF: I 2/3, C 1/1, P 3/3, ML 3/3.
Identification: Small-sized bat. Fur grey to bright rusty brown; underparts always paler at various degrees; pelage long, woolly. Juveniles darker, greyer. Snout haired, red to brown. Forehead profile markedly concave. Ears rather long (40% of forearm); distinctive, angular, deep notch on outer edge; tragus lancet-shaped. Wing greyish to brown, no markings, hairless. Toes with long claws. Tail embedded in uropatagium or slightly extending beyond. No significant sexual dimorphism.

Habitat and habits: Inhabits mesic habitats with abundant vegetation; occurs in coasts, mountains, forests, shrublands, grasslands, human settlements. Roosts in caves, buildings, trees; rarely crevices. Feeds on spiders, flies, moths, lacewings, other insects. Flight slow, agile; can hover while foraging. Gleans prey from surfaces; captures insects in mid-air. Nocturnal. Can enter torpor. Forms maternity colonies; males roost alone or in small groups. Mainly sedentary. Breeding season July–August; gestation may last 1–3 months, 1 young per litter.
Abundance: Scarce.
Conservation status: Global – LC; Regional – DD.

Desert Long-eared Bat
Otonycteris hemprichii (Peters, 1859)

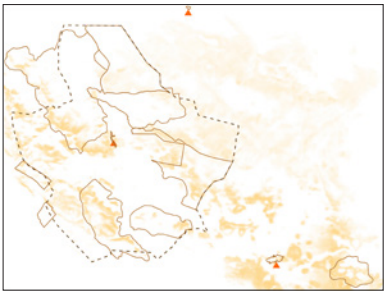


Global distribution: Palaearctic (W, C). Occurs in Morocco, Niger, Arabian Peninsula and up to NW India. Found in Saudi Arabia (NW, C, SE).
Distribution in AlUla: Observed between 850 and 1,210 m a.s.l., can be found in Harrat AlZabin, Harrat Khaybar and Jabal Al Ward.
Measurements: FA: 57–70 mm; EL: 30–42; DF: I 1/3, C 1/1, P 1/2, ML 3/3.
Identification: Medium-sized bat, with robust build. Fur pale beige, underparts whitish to pure white. Muzzle long, narrow. Eyes large. Ears very long; margins smoothly convex, rounded tips. Tragus large. Wings very wide, thick, translucent, hairless; thumb prominent. Tail extends beyond uropatagium by 4–5 mm. No significant sexual dimorphism.

Habitat and habits: Inhabits rocky deserts, semideserts with sparse xeric shrubs; roosts in rock fissures, tree hollows, human-made structures. Forager specialised in scorpions, but also feeds on beetles, spiders, flies, moths, other ground-dwelling arthropods. Flight slow, 'floppy'; forages by ground-gleaning, occasional aerial-hawking; brings food to roost. Adapted to arid conditions; can hibernate, enters daily torpor. Buzz bumblebee-like. Nocturnal. Females, juveniles form maternity colonies; males alone. 2 young per litter.
Abundance: Not evaluated. Due to the lack of confidence in distinguishing this species from *P. christii* based solely on echolocation, the abundance was not evaluated.
Conservation Status: Global – LC; Regional – LC.

Kuhl's Pipistrelle

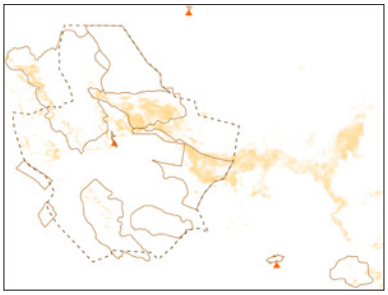
Pipistrellus kuhlii (Kuhl, 1817)



Global Distribution: S Europe, N Africa, Middle East and C Asia. Widespread in Arabian Peninsula.
Distribution in AlUla: Observed between 700 and 1,760 m a.s.l., can be found in Harrat AlZabin, Harrat Khaybar, Old Khaybar and Wadi Nakhlah.
Measurements: BW: 5–10 g; TL: 29–42 mm; FA: 29–37 mm; EL: 9.5–14.5 mm; DF: I 2/3, C 1/1, P 2/2, ML 3/3.
Identification: Small-sized bat. Fur dark brown to yellowish, underparts whitish to white. Forehead profile slightly concave. Ears broad, triangular; tragus tall, narrow. Wings broad with narrow, white border from foot to fifth finger. Tail extends beyond uropatagium by little. No significant sexual dimorphism.

Habitat and habits: Inhabits in agricultural land, urban areas (common), deserts, semideserts, oases. Roosts in buildings, crevices, sometimes hollow trees. Feeds on small flying insects (mosquitoes, moths, beetles). Flight rather high, fast, acrobatic; aerial hawker. Tolerates aridity; may hibernate in colder regions of its range. Forms maternity colonies (hundreds). Mostly sedentary, but short-, medium-distance migrations likely occur. Breeding season August–November; 2 young per litter (usually twins).
Abundance: Abundant.
Conservation status: Global – LC; Regional – LC.

Christie's Long-eared Bat
Plecotus christii (Gray, 1838)



Global distribution: NE Africa and Middle East. Presence reported in Arabian Peninsula.
Distribution in AlUla: Observed between 1,020 and 1,760 m a.s.l., can be found in Harrat Khaybar, Sharaan and Wadi Nakhlah.
Measurements: TL: 41.3–50 mm; FA: 37.8–41 mm; EL: 31.5–38 mm; DF: I 2/3, C 1/1, P 2/3, ML 3/3.
Identification: Small-sized bat. Fur pale to greyish brown; underparts whitish. Face pale, almost hairless; snout blunt, swollen behind nostrils. Large eyes. Ears very long, pale, translucent, joined at base. Wings broad, pale, semi-translucent. Tail almost entirely embedded in uropatagium. No significant sexual dimorphism.

Habitat and habits: Inhabits in deserts, semideserts. Reported in mesic habitats: riparian systems, oases, beaches; uses diverse roosts; caves, buildings, rock crevices, tunnels. Feeds primarily on moths; also grasshoppers, beetles, flies, other insects. Forages by hovering, gleaning. Adapted to arid conditions. Crepuscular to nocturnal. Usually solitary; can form nursery colonies (up to 40). Sedentary. Females lactating mid-April to mid-June. 1 young per litter.
Abundance: Common.
Conservation status: Global – DD; Regional – DD.

Arabian Barbastelle
Barbastella leucomelas

Botta's Serotine
Cnephaeus bottae

Fairy Pipistrelle
Hypsugo ariel

Kuhl's Pipistrelle
Pipistrellus kuhlii

Geoffroy's Myotis
Myotis emarginatus

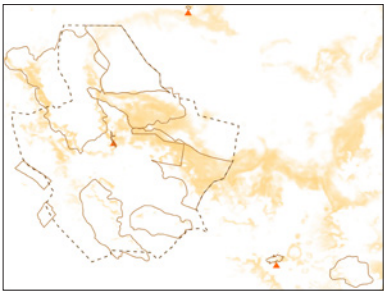
Desert Long-eared Bat
Otonycteris hemprichii

Christie's Long-eared Bat
Plecotus christii

Egyptian Slit-faced Bat
Nycteris thebaica

Arabian Mouse-tailed Bat

Rhinopoma cystops Thomas, 1903



Global distribution: Africa (C, N), Arabian Peninsula and S Asia up to India.
Distribution in AlUla: Observed between 700 and 1,090 m a.s.l., can be found in Harrat Uwayrid, Old Khaybar and Sharaan.
Measurements: TL: 46–73 mm; FA: 47–59 mm; EL: 14–22 mm; DF: I 1/2, C 1/1, P 1/2, ML 3/3.
Identification: Small-sized bat, with light build. Fur sepia grey, underparts paler (grey to whitish). Snout upturned. Noseleaf rudimentary, pointed. Eyes large. Ears large, conjoined across forehead by hairless skin; tragus conspicuous. Wings short, brown. Tail long, slender, mouse-like; mostly free, extends well beyond uropatagium (tail longer than forearm).

Habitat and habits: Inhabits arid, semiarid areas (up to 1,100 m a.s.l.); not found in mesic habitats. Roosts with limbs wide apart in ceilings of caves, ruins, tunnels, old buildings; co-roosts with other bat species. Feeds primarily on insects, including beetles, moths, hymenopterans. Flight fast, moderately high, alternating flutters, glides; cannot hover; climbs nimbly with tail perpendicular to body; forages by slow-hawking, activity inhibited by luminous moonlit nights. Adapted to hot, arid conditions; for winter, stores fat reserves, roosts underground, where it can be unusually light-tolerant. Emerges at dusk. Solitary or forms colonies (a few to hundreds); sexes may segregate outside of mating season. Breeding season February–April; gestation lasts 95–100 days, 1 young per litter.
Abundance: Not evaluated. Due to the lack of confidence in distinguishing this species from *R. microphyllum* based solely on echolocation, the abundance was not evaluated.
Conservation status: Global – LC; Regional – LC.

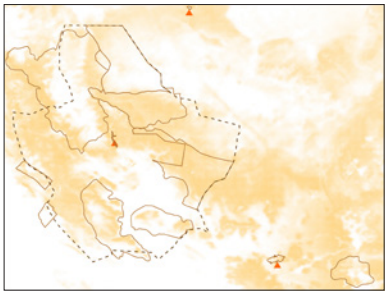
Greater Mouse-tailed Bat

Rhinopoma microphyllum (E. Geoffroy, 1818)

Global distribution: Africa, Arabian Peninsula, India, and possibly SE Asia.
Distribution in AlUla: Due to the lack of confidence in distinguishing this species from *R. cystops* based solely on echolocation, the distribution for this species is not mapped.
Measurements: BW: 14–40 g; TL: 48–63 mm; FA: 61–72 mm; EL: 19–22 mm; DF: I 1/2, C 1/1, P 1/2, ML 3/3.
Identification: Medium-sized bat. Fur greyish-brown or paler; underparts paler to whitish. Face, ears, throat, rump, lower abdomen almost hairless. Snout slightly upturned. Noseleaf rudimentary. Eyes large. Ears large, forward-facing, joined across forehead; tragus sickle-shaped. Wing membrane brown, hairless. Tail slender, long; tail shorter than forearm (in contrast to *R. cystops*); extends beyond uropatagium.

Habitat and habits: Inhabits arid regions with sparse vegetation (up to 1,200 m a.s.l.). Roosts with limbs wide apart in caves, mines, tunnels, buildings; tolerates low humidity; co-roosts with other bat species. Feeds on beetles, various insects; opportunistic on flying ants. Flight fast, alternating flutters, glides; climbs nimbly; forages by slow-hawking. Adapted to arid conditions. Some populations exhibit shallow daytime torpor in winter (may leverage heated geothermal caves); accumulates fat reserves in autumn. Light-tolerant. Nocturnal. Forms large colonies; sexes may segregate. Breeding season March–April; gestation lasts 4 months, 1 young per litter.
Abundance: Not evaluated. Due to the lack of confidence in distinguishing this species from *R. cystops* based solely on echolocation, the abundance was not evaluated.
Conservation Status: Global – LC; Regional – DD.

Pallid Long-fingered Bat
Miniopterus pallidus (Thomas, 1907)

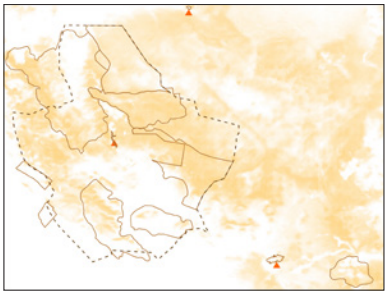


Global distribution: S Europe, Morocco, Turkey, NW Middle East and C Asia. Occurs in SW Saudi Arabia, including Abha and Abha-Raydah.
Distribution in AlUla: Observed between 700 and 1,300 m a.s.l., can be found in all conservation areas except AlUla Oasis and Jabal Nahar.
Measurements: BW: 14.7–15.2 g; TL: 48–62 mm; FA: 44–47.2 mm; EL: 9–12 mm; DF: I 2/3, C 1/1, P 2/3, ML 3/3.
Identification: Medium-sized bat. Fur greyish-brown, may have reddish patches. Ears short, with blunt, slightly forward-curving tragus. Hairs extend onto upper base of tail membrane. Resembles other long-fingered bats, but distinguished by size and slightly more haired tail membrane.

Habitat and habits: Inhabits forests, submontane zones (up to 2,700 m a.s.l.), escarpments, human-modified areas. Roosts in caves, mines or tunnels. Forager specialised in moths; may also hunt beetles, other insects. Apparently nocturnal. Forms large colonies (up to 10,000). Some populations may be migratory.
Abundance: Common.
Conservation status: Global – NT (A2c); Regional – DD.

Geoffroy's Horseshoe Bat

Rhinolophus clivosus (Cretzschmar, 1828)

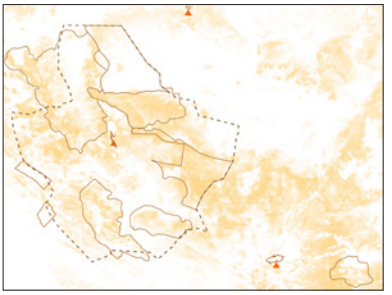


Global distribution: Africa (N, E, S); SW Asia, including Arabia Peninsula: Saudi Arabia, Yemen and Oman.
Distribution in AlUla: Observed between 700 and 1,700 m a.s.l., can be found in all conservation areas except Jabal Shayhoub and Tayma.
Measurements: BW: 10–25 g; TL: 19–38 mm; FA: 45–53 mm; EL: 18–22 mm; DF: I 1/2, C 1/1, P 1-2/2-3, ML 3/3.
Identification: Medium-sized bat. Fur colour highly variable: back grey to reddish-brown (orange forms rare); underparts dull brown-grey. Lower lip with median groove. Noseleaf prominent, with rounded spearhead-shaped lancet. Ears short. Wing membrane is dark grey-brown. No significant sexual dimorphism.

Habitat and habits: Inhabits various open, dry environments: savannas, Mediterranean shrubland, grasslands, semideserts. Roosts in caves, rock crevices, mines, buildings, tree hollows, underground sites. Feeds primarily on moths, beetles; occasionally other insects. Flight highly manoeuvrable; quasi-hoverer. Forages by slow-hawking, fly-catching, perch-feeding, possibly gleaning. Arid-adapted species; uses hibernation, torpor. Nocturnal. Solitary or forms large groups; small colonies in Saudi Arabia. Covers up to 10 km to move between caves. Seasonally monoestrous; gestation lasts 3–5 months, 1 young per litter.
Abundance: Abundant.
Conservation status: Global – LC; Regional – LC.

Lesser Horseshoe Bat

Rhinolophus hipposideros (Bechstein, 1800)



Global distribution: Palaearctic (W, C), N Africa and Middle East; parts of C Asia and Indian subcontinent. Rare in Arabian Peninsula.
Distribution in AlUla: Observed between 490 and 1,760 m a.s.l., can be found in all conservation areas except in AlUla Oasis, Old Khaybar and Tayma.
Measurements: BW: 4–9 g; TL: 22–36 mm; FA: 26–39 mm; EL: 12–18 mm; DF: I 1/2, C 1/1, P 1-2/2-3, ML 3/3.
Identification: Small-sized bat, with light build. Fur grey to yellowish-brown; underparts paler. Ears large, pointed, lacking tragus. Noseleaf distinctive, horseshoe-shaped, almost fully covering snout. Wings brown, broad, rounded. Hind limbs slender, with strong feet. Tail banded. No significant sexual dimorphism.

Habitat and habits: Inhabits in woodlands, shrublands, grasslands, riparian areas, near water bodies; selects natural caves, underground sites, buildings. Feeds on small flying insects (moths, flies, beetles). Flight low, slow, agile, butterfly-like, seldom hovering; forages by slow-hawking, gleaning. Hibernates underground during winter. Nocturnal. Solitary or forms maternity colonies. Breeding season September–November; gestation lasts 67 days, 1–2 young per litter.
Abundance: Abundant.
Conservation status: Global – LC; Regional – NT (VU A2c+R).

Pallid Long-fingered Bat
Miniopterus pallidus

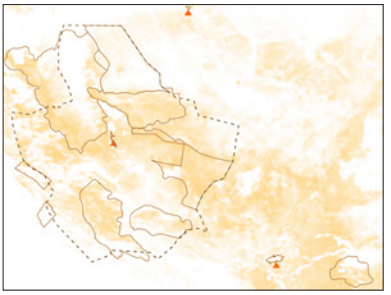
Arabian Mouse-tailed Bat
Rhinopoma cystops

Greater Mouse-tailed Bat
Rhinopoma microphyllum

Geoffroy's Horseshoe Bat
Rhinolophus clivosus

Lesser Horseshoe Bat
Rhinolophus hipposideros

Grey Wolf
Canis lupus (Linnaeus, 1758)

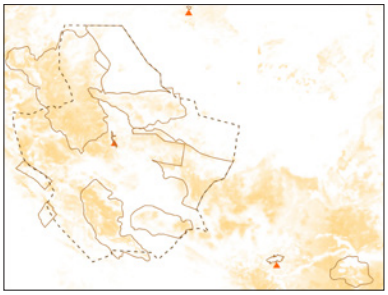


Global distribution: N hemisphere: N America, Europe and Asia, including Arabian Peninsula (widespread records therein).
Distribution in AlUla: Observed between 380 and 1,460 m a.s.l., can be found in all conservation areas except AlUla Oasis, Jabal Al Ward, Jabal Shayhoub and Old Khaybar.
Measurements: BW: 18–20 kg; TBL: 114–140 cm; TL: 31–45 cm; SH: 40–65 cm; HFL: 14–20 cm; EL: 9.2–12 cm; DF: I 3/3, C 1/1, P 4/4, ML 2/3.
Identification: Largest canid in Saudi Arabia, but smaller than counterparts in other areas of distribution range; comparable to medium-sized domestic dogs. Fur short (except long hair on back), greyish-yellow to beige; underparts paler, creamy-white; occasional melanism reported. Cheeks white. Ears large. Middle two toes fused. Tail long, bushy, black-tipped. Males larger. Winter fur thicker, longer, especially around neck. Similar species: Golden Jackal (*C. aureus*) – recorded in AlUla after the completion of this guide, but larger, with longer limbs.

Habitat and habits: Inhabits arid, semiarid regions of Arabian Peninsula. Selects rocky deserts, gravel plains, arid scrublands not distant from water; absent from extensive areas of loose sand. Opportunistic omnivore: feeds on birds, rodents, reptiles, hares, small ungulates, livestock, plants, fruits, berries; scavenges human refuse, carrion. Hunts alone, in pairs, or forms small family groups (3–4). Nocturnal/crepuscular; also occasionally active during morning and mid-afternoon. Howls for communication within pack and possibly with other packs. Territorial only during breeding season. Highly mobile: extensive home range (minimum of 60 km^2), daily movements (up to 10.5 km), long-distance dispersals (up to 200 km). Breeding season October–December; gestation lasts 63–65 days, about 5 young per litter.
Abundance: Abundant.
Conservation status: Global – LC; Regional – VU (C1).

Blanford's Fox

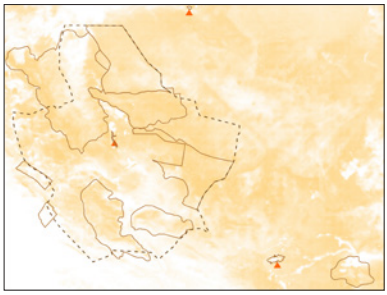
Vulpes cana (Blanford, 1877)



Global Distribution: From Sinai to SC Asia, Afghanistan and Pakistan. Probably occurs along mountains of W Arabian Peninsula: from Jordan to Yemen, Oman and UAE; isolated populations in C Saudi Arabia.
Distribution in AlUla: Observed between 660 and 1,670 m a.s.l., can be found in Harrat AlZabin, Harrat Khaybar, Harrat Uwayrid, Jabal Al Ward and Wadi Nakhlah.
Measurements: BW: 0.8–1.4 kg (M), 0.8–1.6 kg (F); TBL: 73–76.2 cm; TL: 32.4–36 cm; SH: 26–28 cm; HFL: 9.2–10.1 cm; EL: 7.6–8.8 cm; DF: I 3/3, C 1/1, P 4/4, ML 2/3.
Identification: Very small-sized fox. Fur brownish grey, with dark mid-dorsal stripe extending into tail; underparts white to pale yellow. Head orange buff, especially in winter; face narrow, with dark band from upper lip to eye. Eyes dark. Ears large, pale brown, with long white hairs on inner front side. Paws whitish, small; pads hairless; claws sharp, curved. Tail very long, very bushy, with dorsal black spot at base, black or white tip. Males slightly larger. Winter fur darker, denser. Similar species: Rüppell's Fox (*V. rueppellii*), but slightly smaller, tail longer, bushier, ears smaller; Red Fox (*V. vulpes*), but much smaller, tail relatively longer, ears not black-backed, tail not only white-tipped.
Habitat and Habits: Inhabits dry foothills, mountainous regions below 2000 m a.s.l.; Absent from higher mountain ranges, open desert. Occupies steep, rocky slopes, canyons, cliffs, creek bed patches. Dens in rock clefts, does not dig; very agile, formidable climber. Omnivorous: feeds on insects (beetles, grasshoppers, ants, termites), fruits (caperbush, wild figs, dates, apples), small mammals, lizards, birds. Rarely drinks water. Solitary forager; rarely caches food. Nocturnal. Territory 1.6 km^2; territories overlap slightly. Monogamous; breeding season December–February; gestation 50–60 days, 1–4 young per litter.
Abundance: Abundant.
Conservation status: Global – LC; Regional – VU (C1).

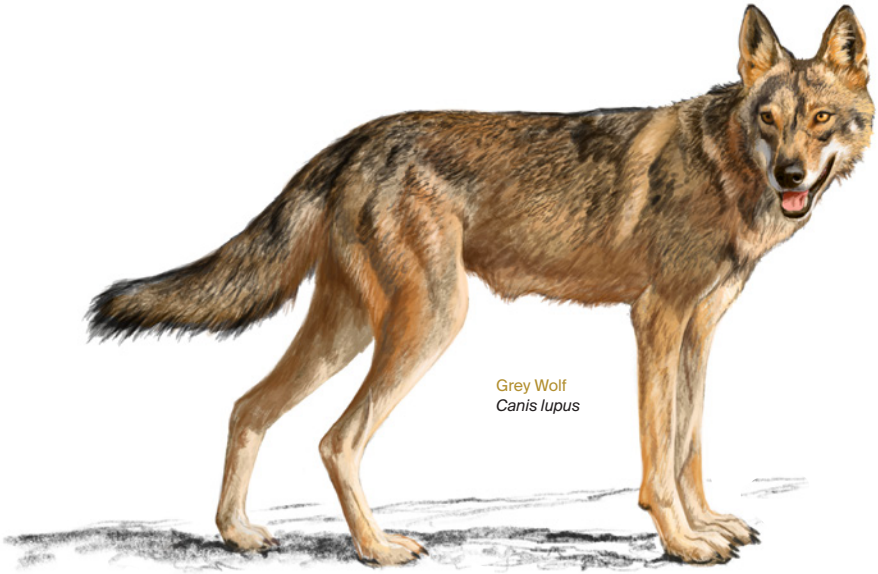
Red Fox

Vulpes vulpes (Linnaeus, 1758)

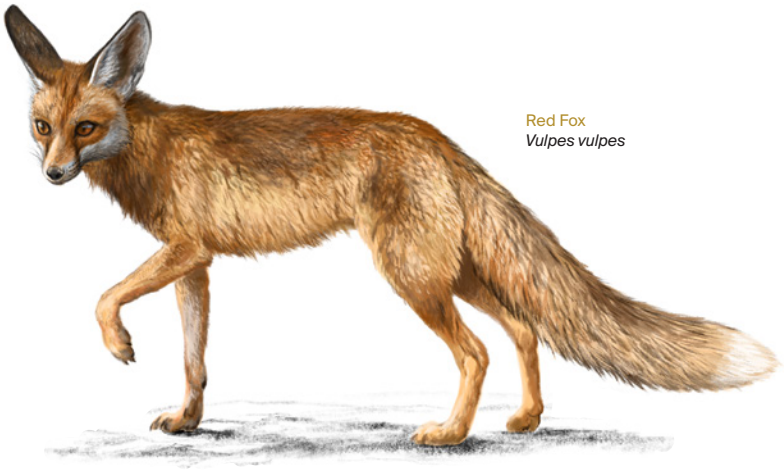


Global distribution: N hemisphere: Europe, N Africa, Asia and N America; introduced in Australia. Common in Arabian Peninsula, including Saudi Arabia.
Distribution in AlUla: Observed between 240 and 1,790 m a.s.l., can be found in all conservation areas.
Measurements: BW: 2.4–3.2 kg (M), 2–3 kg (F); TBL: 60.7–103.5 cm; TL: 24–41.2 cm; SH: 32.5–37.5 cm; HFL: 10–15.5 cm; EL: 6.7–10.9 cm; DF: I 3/3, C 1/1, P 4/4, ML 2/3.
Identification: Largest fox in Saudi Arabia, but smaller than counterparts in other areas of distribution range. Fur short, pale reddish brown; underparts whitish to blackish. Muzzle slender, pointed; upper lip white. Ears very large, erect, black-backed. Paws white; fur between toes. Tail bushy, dull fulvous to buffy white, black-haired, sometimes white-tipped. Females 15% smaller. Winter fur longer, with darker hues. Similar species: Rüppell's Fox (*V. rueppellii*), but larger, relatively smaller ears, fur not uniform creamy-white to pale rufous; Blanford's Fox (*V. cana*), but larger, tail less conspicuous, ears less prominent, pads not hairless.

Habitat and habits: Inhabits diverse environments, including sandy deserts, rocky mountains, urban areas; absent from extensive dune areas. Thrives in mixed landscapes, edge habitats affected by anthropogenic activities. Dens in self-excavated burrows. Opportunistic omnivore: feeds on invertebrates, small mammals, birds, fruits, plants, carrion. Solitary. Mainly nocturnal. Not territorial; forms loose groups (up to 4). Nomadic; home range mostly never permanent. Breeding season December–February; gestation lasts 49–56 days, 5 young per litter.
Abundance: Abundant.
Conservation status: Global – LC; Regional – LC.



Grey Wolf
Canis lupus



Red Fox
Vulpes vulpes

Blanford's Fox
Vulpes cana

Cheetah

Acinonyx jubatus (Schreber, 1775)

Global distribution: Sub-Saharan Africa, N Africa and Iran. Historically present but now extinct in Arabian Peninsula, including Saudi Arabia.
Distribution in AlUla: This species is locally extinct in AlUla since the early 20th century, although reintroduction programmes of captive-born animals may be planned in the future.
Measurements: BW: 25–38 kg (M), 23–35 kg (F); TBL: 162–259 cm (M), 222–266 cm (F); TL: 62–77 cm; SH: 51–87 cm; DF: I 3/3, C 1/1, P 3/2, ML 1/1.
Identification: Slim-built cat, smaller than counterparts in other areas of distribution range. Fur pale fawn to yellow, with round solid black spots; mane darker; underparts paler. Face with distinctive black stripes (tear lines) from eyes to mouth; muzzle short; head small, rounded. Ears small, with black, white markings behind. Limbs slender, slim; semi-protractile claws. Tail long, ringed, black-spotted, broader at tip than base, white tip. Males slightly larger. Winter fur longer, denser. Mane on nape in cubs. Similar species: Arabian Leopard (*P.p nimr*), but body much less robust, spots do not form rosettes.

Habitat and habits: Inhabits plains, salt-pans, eroded foothills, rugged desert ranges. Feeds on medium-sized ungulates, small mammals; rarely livestock. Hunts by sight, stalking, sprinting; subdued prey can be usurped by larger predators. Adapted to arid conditions; can survive with minimal water. Mainly diurnal, occasionally nocturnal in areas of high human disturbance; active mainly during cooler hours of dawn and dusk. Solitary or in family groups of mother and cubs; males, mostly brothers, form coalitions. Males territorial. Home ranges extensive (5,000 km^2), overlapping. Breeding season January–February; gestation lasts 90 days, 1–4 young per litter.
Abundance: Not evaluated, due to lack of recent observations in the region.
Conservation status: Global – VU (A4b; C1); Regional – RE.

Caracal

Caracal caracal (Schreber, 1776)

Global distribution: From S Africa to Asia (C, SW). In Arabian Peninsula, from SW mountains of Saudi Arabia to Dhofar, Musandam (Oman) and N UAE. Occurs in S Yemen, Wadi el Kabir and Dhala. Sparse in extensive desert regions.

Distribution in AlUla: Observed at 1,410 m a.s.l., can be found in Harrat Uwayrid.

Measurements: BW: 4–13.6 kg (M), 5.9–9.2 kg (F); TBL: 80–107 cm; TL: 10–28.5 cm; SH: 27–47 cm; EL: 7–8.2 cm; DF: I 3/3, C 1/1, P 3/2, ML 1/1.

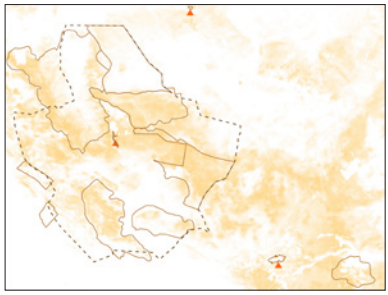
Identification: Medium-sized cat, smaller than counterparts in other areas of distribution range; long-legged, with stocky build. Fur short, dense, uniform light sandy to pale reddish-brown, unspotted; underparts whitish. Arabian Caracal has uniform light sandy brown back, grizzled with white hair tips. Chin, throat white; black stripe from nose to eye. Ears long, silvery-black, dark-backed, with prominent black tufts. Hind limbs longer than front limbs; paws furry. Tail short. Males larger. Winter fur longer, denser.

Habitat and habits: Inhabits semideserts with sufficient vegetation, shelter cover; absent from true desert areas. Found in foothill trails, dry riverbeds, *wadis*. In Saudi Arabia, occurs in hilly steppe deserts, mountain terrains with tamarisk thickets, rock crevices. Feeds mostly on birds, small mammals, reptiles; also medium-sized mammals, insects, poultry, carrion; in Oman, hunts gazelles, lizards, snakes. Very powerful, agile; can jump high to catch birds; superior climbing proficiency. Adapted to dry conditions, can rely on prey for moisture. Nocturnal/crepuscular; active during daytime in less disturbed habitats. Solitary; males' home ranges much wider, females' overlapping. Breeding season January–February; gestation lasts 82 days, 2–5 young per litter.

Abundance: Rare.

Conservation status: Global – LC; Regional – LC.

Afro-Asiatic Wildcat
Felis lybica (Forster, 1780)



Global distribution: Across Africa and Asia: from Arabian Peninsula to C Asia, India, Mongolia and N China.
Distribution in AlUla: Observed between 520 and 1,380 m a.s.l., can be found in all conservation areas except AlUla Oasis, Harrat Khaybar, Jabal Shayhoub, Old Khaybar and Tayma.
Measurements: BW: 2.4–6 kg; TBL: 63–90 cm; TL: 26–36 cm; SH: 30–35 cm; DF: I 3/3, C 1/1, P 3/2, ML 1/1.
Identification: Size comparable to large domestic cat, but build more slender. Fur highly variable, but typically short, pale sandy-brown to grizzled light/dark grey; back, flanks with grey-black to brown spots or stripes; limbs with marked stripes; stripes, spots not always present; underparts whitish to buff. Nose with orange hue; white below eyes. Ears triangular, pointed, with short tuft on top. Pads black. Tail rather long, with 2–3 dark subterminal rings and black tip. Similar species: Caracal (*C. caracal*), but size smaller, ear tufts shorter, fur colour not as uniform, tail relatively longer; Sand Cat (*F. margarita*), but size larger, face not broad, ears not rounded, fur not pale sandy-buff.

Habitat and habits: Inhabits environments with sufficient vegetation, shelter cover. In Arabian Peninsula, occupies semideserts, rocky areas, xeric shrublands, woodlands, grasslands, agricultural fields, areas near human settlements; absent from extensive sand dunes. Dens in burrows excavated by other species, but can also dig its own. Feeds mostly on rodents; also birds and young of hares, hyraxes, gazelles; rarely reptiles, insects, fruits (dates); scavenges occasionally. Relies on stealth for hunting; adept climber. Nocturnal/crepuscular. Solitary, territorial. Breeding season January–March (Sahara); gestation lasts 56–65 days, 1–5 young per litter.
Abundance: Abundant.
Conservation status: Global – LC; Regional – NT (VU A2).

Sand Cat

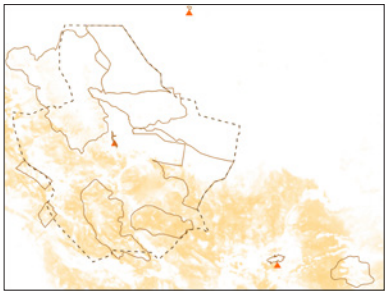
Felis margarita (Loche, 1858)

Global distribution: N Africa, Arabian Peninsula, C Asia, Iran and Pakistan. Distribution sparse, patchy.
Distribution in AlUla: Observed at 1,000 m a.s.l., can be found in AlGharameel.
Measurements: BW: 2–2.5 kg (M), 1.8 kg (F); TBL: 66–92.5 cm (M), 65–83.5 cm (F); TL: 22–35.5 cm; SH: 25–30.5 cm; DF: I 3/3, C 1/1, P 3/2, ML 1/1.
Identification: Small cat; smallest Arabian cat. Fur pale sandy-buff, with 7–8 subtle reddish-black vertical stripes, fragmented into spots; underparts white; limbs with dark horizontal stripes. Head broad, flat; reddish stripes from eyes across cheeks; crown darkly striated. Eyes large, yellow-amber to greenish. Ears large, black-tipped, low-set, widely apart. Toes and pads fully black-haired. Tail rather long (half body length), with 2–9 dark rings, black-tipped. Males larger. Winter fur denser, longer, darker dorsally, with geometric patterns less visible. Kittens' fur greyer, with geometric patterns more visible.

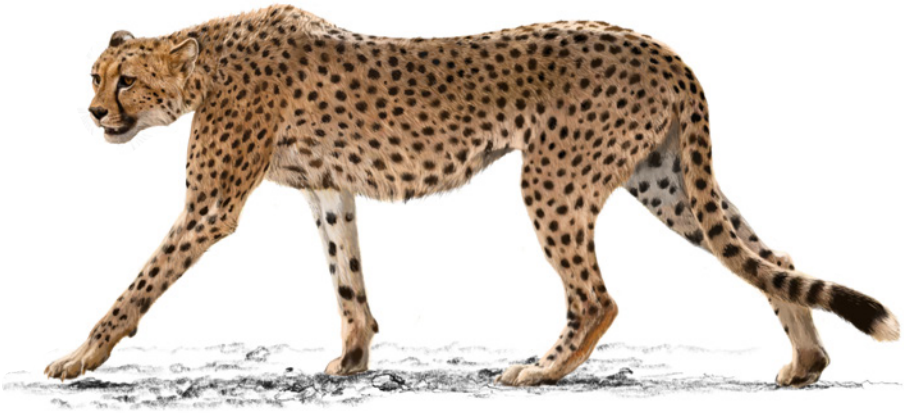
Habitat and habits: Inhabits sandy, rocky terrains with sparse vegetation. In Saudi Arabia, recorded in protected areas, sandy deserts. Proficient digger; only Arabian cat that digs its own burrow; also dens in burrows of other species. Feeds mostly on insects, reptiles; also small mammals (up to young hares' size), birds. Employs acute hearing for prey detection; conceals killed prey under sand and returns later to feed. Independent of free water; moisture from prey sufficient, but drinks when possible. Adapted to arid conditions. Mainly nocturnal; partly diurnal in winter. Solitary excluding mating season; home range extensive (20–51 km^2), uses same burrow year-round; males' territories overlap. Mating call loud, similar to small dog barking. Breeding season varies across distribution range; gestation lasts 59–67 days, 2–8 young per litter.
Abundance: Rare.
Conservation status: Global – LC; Regional – VU (C1).

Arabian Leopard

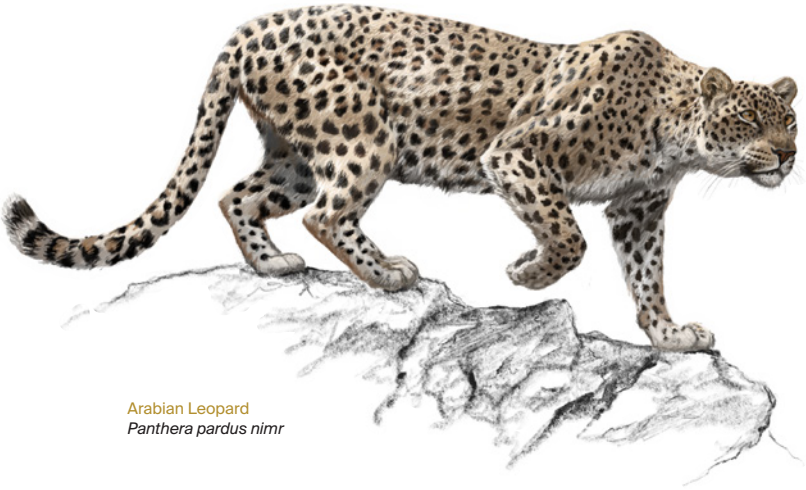
Panthera pardus nimr (Hemprich & Ehrenberg, 1833)



Global distribution: Stable population in Dhofar mountains (Oman). In Saudi Arabia, reported from Asir, Sarawat and Hejaz mountains. Reported from Yemen.
Distribution in AlUla: There are historical observations in Harrat AlZabin, Harrat Uwayrid, Jabal Al Ward and Jabal Nahar, but the species is apparently extinct in AlUla, with the last confirmed record in 2002 (Harrat AlZabin). Reintroduction programmes are being planned by captive breeding individuals, habitat and prey restoration, and initiating community engagement programmes.
Measurements: BW: 26–34 kg (M), 18–23.5 kg (F); TBL: 160–226.1 cm; TL: 66–94 cm; SH: 50–75 cm; EL: 4.4 cm (1); DF: I 3/3, C 1/1, P 3/2, ML 1/1.
Identification: Largest Arabian felid; smaller than other leopard subspecies. Body robust anteriorly, slender posteriorly. Fur very pale, spotted with black rosettes (unique patterns); back deep golden-yellow; underparts white; rest of body beige to greyish-white. Head large, sturdy, spotted more densely; chin white. Vibrissae long, eyebrows very long. Ears relatively small, white-, black-backed. Limbs stout, paws broad. Tail long. Males larger. Cubs' fur paler, greyer, longer. Similar species: Cheetah (*A. jubatus*), but body much more robust, rosettes instead of simple dots.
Habitat and habits: Inhabits arid, semiarid regions. Selects remote, mountain ranges (>1,000 m a.s.l.), semideserts, scrublands, rocky *wadis* close to permanent water, with vegetation sufficient for cover, prey species sustenance; absent from open deserts. Feeds primarily on ungulates, hare, hyrax, partridges; also rarely on young livestock. Stalks, ambushes prey; caches carcasses in caves, lairs, but not trees. Tolerates water scarcity. Mostly nocturnal; diurnal where undisturbed by humans. Solitary, territorial; home range 75 km^2; males' territory overlaps females'. Breeds year-round; gestation lasts 90–106 days, 1–3 young per litter.
Abundance: Not evaluated, due to lack of recent observations in the region.
Conservation status: Global – CR (C2a(i)); Regional – CR (C2a(i)); Regional – CR (C2a(i)).



Cheetah
Acinonyx jubatus



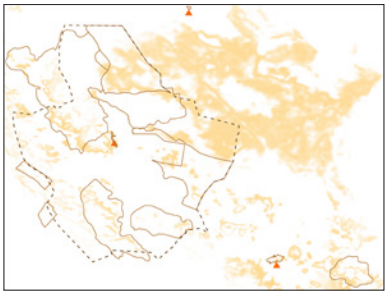
Arabian Leopard
Panthera pardus nimr

Caracal
Caracal caracal

Afro-Asiatic Wildcat
Felis lybica

Sand Cat
Felis margarita

Striped Hyena
Hyaena hyaena (Linnaeus, 1758)



Global distribution: Africa (N, E), Arabian Peninsula to Turkey, Caucasus, C Asia and India. In Saudi Arabia, found mainly in western mountains.
Distribution in AlUla: Observed between 700 and 1,130 m a.s.l., can be found in AlGharameel, Harrat Uwayrid and Old Khaybar.
Measurements: BW: 18–20 kg; TBL: 125–154 cm; TL: 26–29.5 cm; SH: 66–75 cm; HFL: 18–23 cm; EL: 13–16.5 cm; DF: I 3/3, C 1/1, P 4/3, ML 1/1.
Identification: Large-sized, robust carnivoran, comparable to wolf, dog, but with sloping-back profile; appearance smaller, darker than counterparts in other areas of distribution range. Fur short, coarse, shaggy, buffish to yellowish-tawny; dorsal mane grey-black; flanks with black vertical stripes; limbs with horizontal stripes; throat with distinctive dark patch. Head large, broad; dark stripe on cheek; muzzle dark, pointed. Ears long, pointed. Neck thick. Mane more pronounced than in other hyaenids; can be erected to increase apparent size. Forelimbs longer than hind limbs. Tail long, shaggy. No significant sexual dimorphism in size. Cubs' fur pale white, striped, maneless. Winter fur longer.
Habitat and habits: Inhabits arid, semiarid regions. Selects valleys, lava fields, scrub woodlands, mountainous terrains, agricultural areas, human settlements. Absent from dense thickets, open deserts. Primarily scavenges carrion of large-, medium-sized mammals, anthropogenic refuse; can break bones open to feed on marrow; feeds also on fruits (dates, hegligs, cucurbits), insects; occasionally hunts small animals. Adapted to scarce water sources; regularly drinks but can survive in water-deficient areas. Primarily nocturnal. Solitary (males) or in pairs; rare groupings at dense food sources; home range vast. Polyestrous, non-seasonal breeder; gestation lasts 90–91 days, 1–5 young per litter.
Abundance: Scarce.
Conservation status: Global – NT (C1); Regional – VU (C1).

Honey Badger

Mellivora capensis (Schreber, 1776)

Global distribution: S Africa to Arabian Peninsula, C Asia and India. Rare in arid regions. Scarce but widespread in Arabian Peninsula.
Distribution in AlUla: Observed between 570 and 850 m a.s.l., can be found in Jabal Nahar.
Measurements: BW: 8.0–11.2 kg (M), 5.2–7.1 kg (F); TBL: 78.8–92.7 cm; TL: 19–24.6 cm; HFL: 10.1–10.8 cm; DF: I 3/3, C 1/1, P 3/3, ML 1/1.
Identification: Medium-sized mustelid (closer to upper side of this category); body compact, robust. Fur grey-white; underparts black; contrast marked, distinctive created by pure white band. Skin thick, loose; anti-predator defence mechanism. Facial markings are subtle; vary regionally. Ears very short. Forelimbs strong, claws large for digging, hind claws less sturdy. Tail short. Males larger. Fur colour varies regionally.

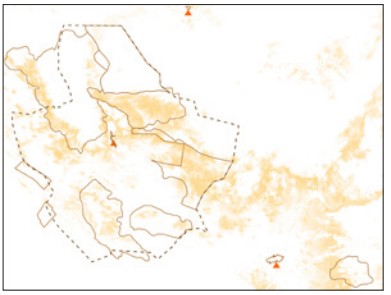
Habitat and habits: Inhabits arid, semiarid environments. In Arabian Peninsula, occurs in *wadis*, sandy-gravel deserts, mountains, plateaux; absent from extensive sand dunes. Opportunistic carnivore; feeds on small mammals, insects, reptiles, birds, fruits, roots. Known for raiding beehives. Nocturnal; diurnal with low human disturbance. Solitary; occasional maternal pairs or groups at food sources. Nomadic, non-territorial; covers vast areas in search of food. Breeds year-round; gestation lasts 50–70 days, 1–2 young per litter.
Abundance: Scarce.
Conservation status: Global – LC; Regional – NT (VU C1).

Striped Hyena
Hyaena hyaena

Honey Badger
Mellivora capensis

Nubian Ibex

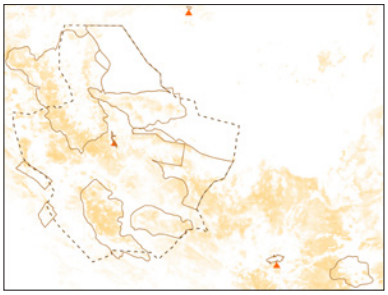
Capra nubiana (F. Cuvier, 1825)



Global distribution: NE Africa to Arabian Peninsula. Reported in Egypt, Sudan, Palestine, Jordan, Saudi Arabia, Yemen and Oman. Formerly present in Lebanon and Syria. Reintroduced in Syria. Patchy distribution.
Distribution in AlUla: Observed between 730 and 1,280 m a.s.l., can be found in Harrat AlZabin, Sharaan and Wadi Nakhlah. This species was almost extinct in AlUla, and current populations result mostly from reintroduction programmes of captive-born animals.
Measurements: BW: 50–85 kg (M), 25–50 kg (F); TBL: 110.5–142.3 cm; TL: 5.6–8.3 cm; HL: 38–52.7 cm (M), 17.4–19.6 cm (F); SH: 60.9–76.2 cm (M); EL: 10.7–11.2 cm; DF: I 0/3, C 0/1, P 3/3, ML 3/3.
Identification: Smallest of ibex, with light build. Fur pale brown to red-sandy, with posterior body half lighter; underparts white; mid-dorsal stripe dark; rump with small, white patch. Ears large. Horns curved (form 3/4 of circle), scimitar-like. Tail black, tufted. Males markedly larger, with dark beards (7–10 cm), dark stripe on back, forelimbs; larger horns with transverse knobs (24–36); possible silver saddle, black markings in winter fur or during October rut, when fur overall darkens. Females stripeless. Similar species: Domestic Goat (*Capra hircus*), but larger, fur short, variable fur patterns absent.
Habitat and habits: Inhabits arid, semiarid, mountainous regions. Occurs in steep, rocky slopes, *wadis*. Herbivorous; feeds on acacias, shrubs, leaves, grasses. Adapted to arid, hot conditions. Water source availability crucial; drinks almost daily. Diurnal; daytime activity inhibited by intense heat. Gregarious: mixed, single-sex family groups; linear dominance hierarchy in females. Home range 0.5–15 km^2; moves daily 4–6 km, seasonally based on rain, up to 10 km for males in mating season. Breeding season late summer months to October; gestation lasts 150 days, 1–2 young per litter.
Abundance: Common.
Conservation status: Global – VU (C1+2a(i)); Regional – VU (C1).

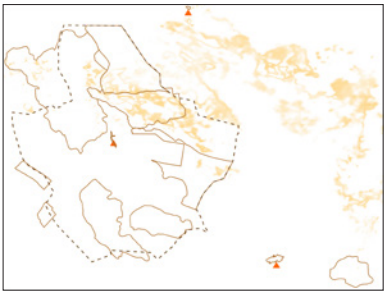
Arabian Gazelle

Gazella arabica (Lichtenstein, 1827)



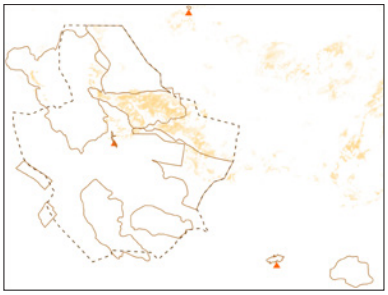
Global distribution: Saudi Arabia, Oman and UAE; reintroduced populations in Saudi Arabia. Possibly present in Yemen. Historically inhabited vast areas across Arabian Peninsula.
Distribution in AlUla: Observed between 280 and 1,240 m a.s.l., can be found in Harrat AlZabin, Harrat Uwayrid, Jabal Shayhoub and Sharaan. This species was almost extinct in AlUla, and current populations result mostly from reintroduction programmes of captive-born animals.
Measurements: BW: 15–20 kg; TBL: ~109 cm; TL: ~9 cm; HL: 15–27 cm (M), 5.8–11.5 cm (F); SH: ~60 cm; DF: I 0/3, C 0/1, P 3/3, ML 3/3.
Identification: Small gazelle, slim-built. Fur colour variable, always tones of buff, typically sandy to reddish-brown; underparts pure white; flanks black-striped; rump with prominent white patch; overall marked colour contrasts. Face with distinct markings; nose black-spotted. Horns with transverse knobs (only males); more developed in males. Tail short, with black terminal tuft. Arabian populations show morphological variations. Similar species: Sand Gazelle (*G. marica*), but fur darker, face pattern conspicuous, horns shorter.
Habitat and habits: Inhabits diverse landscapes: deserts, grasslands, gravel/coastal plains, *wadis*, shrublands, hillsides, mountains; absent from areas with loose sand (in contrast to *G. marica*). Selects areas abundant in acacias, *Cyperus*/*Vachellia* plants, refuges. Herbivorous, primarily grazer; typically feeds on acacia leaves, flowers, fruits, bulbs, corms. Does not need to drink water. Crepuscular; diurnal in areas undisturbed by humans. Solitary (males) or forms small groups (up to 6). Males highly territorial; only females' home ranges overlap. Sedentary. Breeds twice a year, births peak spring, autumn; gestation lasts 180 days, 1 young per litter.
Abundance: Common.
Conservation status: Global – VU (C2a(i)); Regional – VU (C2a(i)).

Sand Gazelle
Gazella marica (Thomas, 1897)



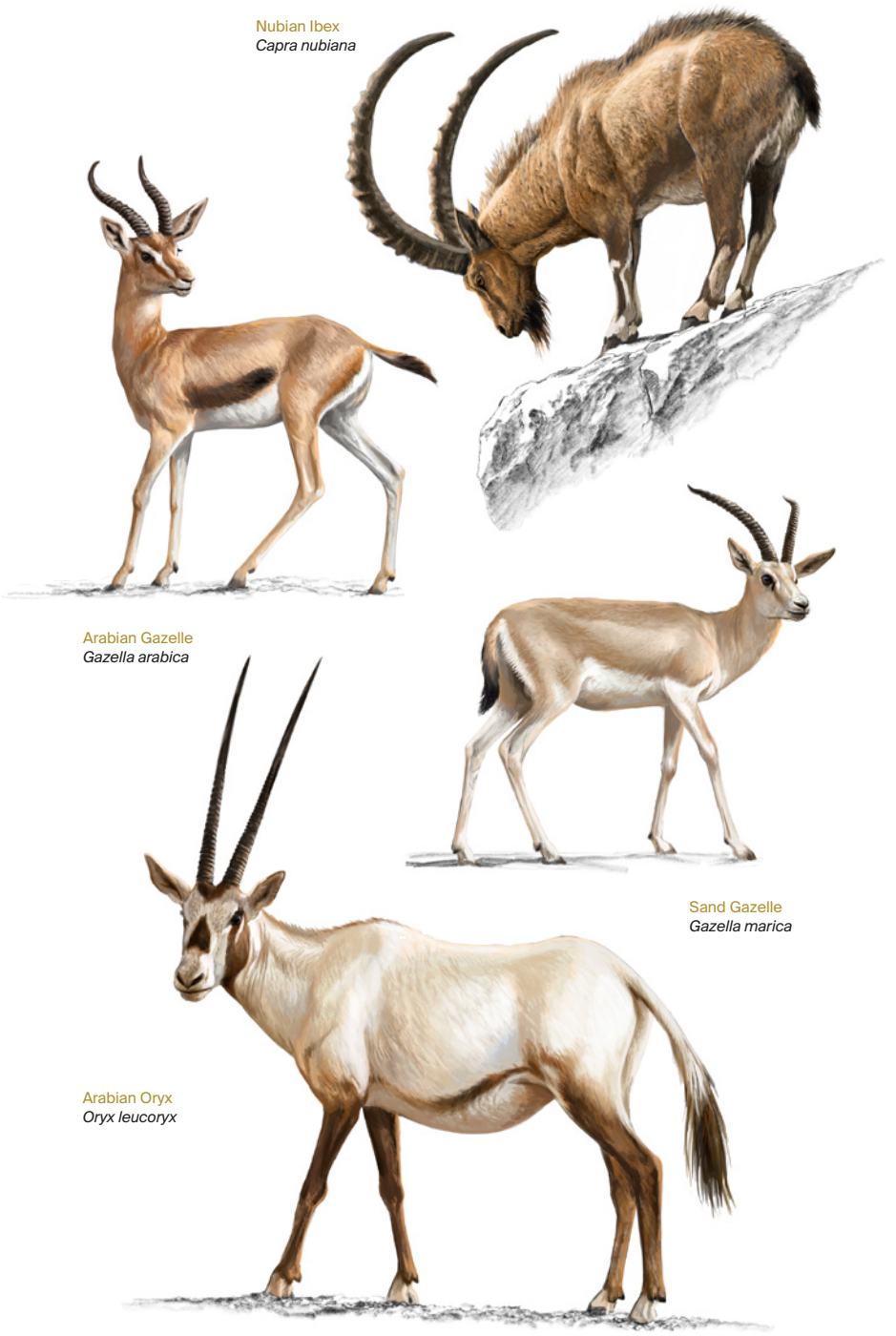
Global distribution: Arabian Peninsula: S Syria to Oman. Possibly present in Turkey, Iraq and Iran. Originally widespread across Arabian Peninsula.
Distribution in AlUla: Observed between 950 and 1,080 m a.s.l., can be found in Sharaan. This species was almost extinct in AlUla, and current populations result mostly from reintroduction programmes of captive-born animals.
Measurements: BW: 15–28 kg (M), 11–24 kg (F); TBL: 94–99.3 cm; TL: 14.4–16 cm; HL: 20.3–42.5 cm (M), 7.1–28.5 cm (F); SH: 60–72 cm (M), 54–67 cm (F); HFL: 27.2 cm (1); EL: 12.5 cm (1); DF: I 0/3, C 0/1, P 3/3, ML 3/3.
Identification: Slim-built even-toed ungulate. Fur whitish to light yellow-brown, with a reddish hue on back; underparts white. Face white; mouth, nose, eyes black. Eyes large. Males' horns prominent, long, curved, with hooked, sharp tips; females' shorter, straight, sometimes absent. Throat has goitre-like enlargement for mating calls, more developed in males. Tail black. Males slightly larger. Similar species: Arabian Gazelle (*G. arabica*), but fur lighter-coloured with faint patterns, horns longer, occupies different habitats.
Habitat and habits: Inhabits coastal flats, sandy deserts, gravel plains, limestone plateaux, basaltic lava fields, sedimentary escarpments; absent from mountains. Herbivorous; feeds on leaves, grasses, young shoots. Does not need to drink water. Uses heterothermy for water conservation; can tolerate up to 42.5°C. Forms small family groups (2–10) in summer, large groups (hundreds) in winter or post-rainfall. Highly nomadic, capable of long migrations in search of rainfall-induced greenery; territorial in winter. Breeding season September–January; gestation lasts 150–180 days, 1–4 young per litter (typically 2 twins).
Abundance: Scarce.
Conservation status: Global – VU (C2a(i)); Regional – VU (C2a(i)).

Arabian Oryx
Oryx leucoryx (Pallas, 1777)



Global distribution: Originally widespread across Arabian Peninsula. Reintroduced in Palestine, Jordan, Saudi Arabia, UAE and Oman.
Distribution in AlUla: Observed between 880 and 1,080 m a.s.l., can be found in Sharaan and AlGharameel. This species was locally extinct in AlUla, and current populations result from reintroduction programmes of captive-born animals.
Measurements: BW: 65–75 kg (M), 54–70 kg (F); TBL: 132.7–177.8 cm; TL: 19–25.4 cm; HL: 53–74 cm; SH: 71.1–102 cm; EL: 12.2 cm (1); DF: I 0/3, C 0/1, P 3/3, ML 3/3.
Identification: Medium-sized even-toed ungulate, with robust build; largest Arabian antelope, but smallest oryx. Fur mainly bright white, with cream to brown variations. Face with distinct dark markings on cheeks, nose, forehead. Horns, slender, slightly backward-pointing; females' slightly thinner, longer. Mane sparse. Hump over withers. Limbs chocolate-brown to black; white patches above hooves. Tail dark-tipped, bushy. Calves' fur sandy-coloured, brown-shaded; markings only on knees, tail.

Habitat and habits: Inhabits deserts, semideserts, arid plains, barren steppes, rocky slopes. Herbivorous, primarily grazer; feeds on grasses, leaves, buds, shrubs, succulent roots. Can survive on poor-quality forage. Adapted to arid conditions; tolerates prolonged water deprivation. Adapted to intense heat: utilises heterothermy, selective brain cooling. Diurnal; nocturnal in summer, cathemeral in extreme heat. Forms mixed groups (2–15, typically 10); larger herds observed. Nomadic, presumed to detect, follow rainfall; daily movements extensive (50 km); home range extensive in spring, smaller in summer. Does not return to grazed areas for months. Polyestrous; breeding season varies (peaks spring, autumn); gestation lasts 255–270 days, 1 young per litter.
Abundance: Common.
Conservation status: Global – VU (D1); Regional – VU (D1).


Nubian Ibex
Capra nubiana
Arabian Gazelle
Gazella arabica
Sand Gazelle
Gazella marica
Arabian Oryx
Oryx leucoryx

9. Important Mammal Areas

The most important areas for mammals, according to the distribution of mammal species richness, are located in Sharaan, Wadi Nakhlah, and the western and eastern slopes of Harrat Uwayrid (**Figure 9**).

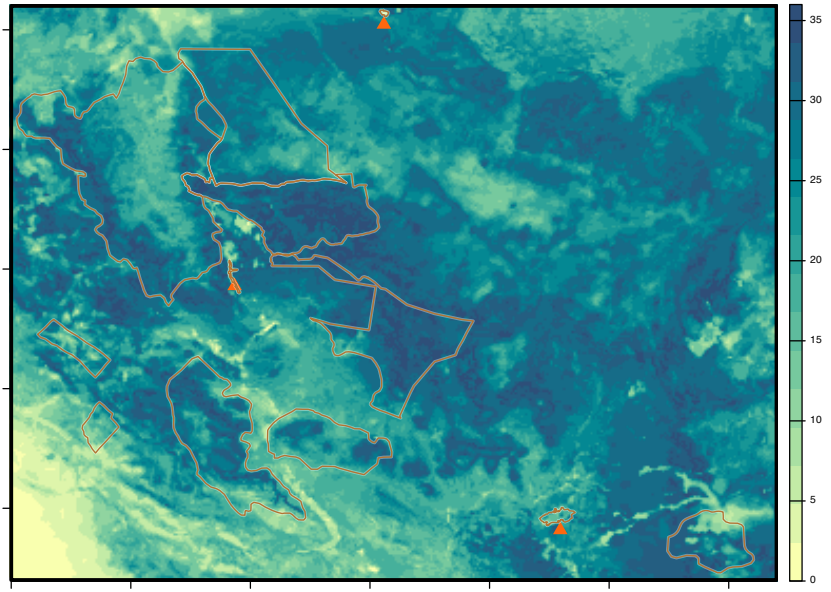


Figure 9 Distribution of mammal species richness in the AlUla region. The legend on the right indicates the number of species.

10. Echolocation of the Bats of AlUla

Species	FMaxE	Fstart	Fend	Duration	Shape
Rousettus aegyptiacus	23–35	25–159	7–27	0.3–2	FM
Asellia tridens	105–123	105–130	94–123	6–14	CF
Nycteris thebaica	68–91	75–83	61–66	1–3	FM
Tadarida aegyptiaca	14–25	17–35	6–24	3–16	QCF
Tadarida teniotis	10–20	14–28	8–18	7–27	QCF
Taphozous nudiventris	22–26	22–28	20–24	7–19.5	QCF
Barbastella leucomelas	32–37	34–42	22–35	2–7	QCF
Cnephaeus bottae	29–37	38–56	27–34	2–10	QCF
Hypsugo ariel	33–50	36–87	28–48	2–15	QCF
Myotis emarginatus	45–79	73–121	39–49	1–5	FM
Otonycteris hemprichii	16–33	28–68	15–26	1–12	FM
Pipistrellus kuhlii	36–47	39–67	34–45	2–13	QCF
Plecotus christii	25–36	33–49	20–27	1–4	FM
Rhinopoma cystops	30–37	33–40	29–36	4–12	QCF
Rhinopoma microphyllum	26–32	28–38	23–31	3–13	QCF
Miniopterus pallidus	52–58	58–61	30–57	4–6	QCF
Rhinolophus clivosus	80–94	72–75	62–90	9–64	CF
Rhinolophus hipposideros	101–111	80–112	82–111	30–61	CF

Table 2 Descriptive parameters of echolocation calls of the 18 bat species present in AlUla. FMaxE – frequency with maximum energy in kHz; Fstart – start frequency in kHz; Fend – end frequency in kHz; Duration – pulse duration in ms; Shape – dominant pulse shape. Values show the range (minimum and maximum) and were compiled based on available literature.

Egyptian Rousette
Rousettus aegyptiacus (E. Geoffroy, 1810)

FMaxE: 23–35 kHz; Fstart: 25–159 kHz; Fend: 7–27 kHz; Duration: 0.3–2 ms. Pulse with brief, broadband tongue clicks (“dry sound”).

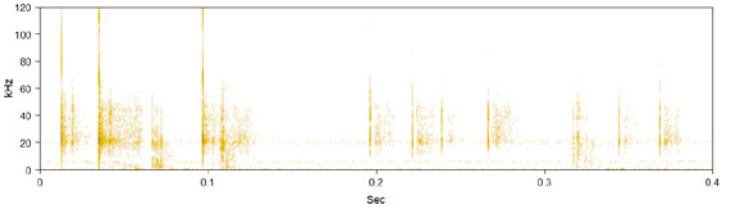


Figure 10 Sonogram depicting echolocation calls of *Rousettus aegyptiacus*.

Geoffroy’s Trident Leaf-nosed Bat
Asellia tridens (E. Geoffroy, 1813)

FMaxE: 105–123 kHz; Fstart: 105–130 kHz; Fend: 94–123 kHz; Duration: 6–14 ms. Pulse with dominant CF section with long broadband FM component at the end.

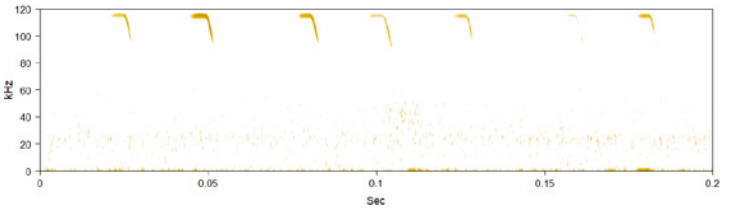


Figure 11 Sonogram depicting echolocation calls of *Asellia tridens*.

Egyptian Free-tailed Bat
Tadarida aegyptiaca (E. Geoffroy, 1818)

FMaxE: 14–25 kHz; Fstart: 17–35 kHz; Fend: 6–24 kHz; Duration: 3–16 ms. Pulse with dominant narrowband QCF, sometimes containing a small initial FM component. Not always distinguishable from *Tadarida teniotis* due to overlap in FMaxE between 14 and 20 kHz.

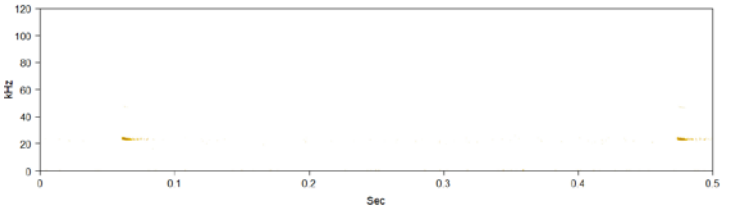


Figure 12 Sonogram depicting echolocation calls of *Tadarida aegyptiaca*.

European Free-tailed Bat
Tadarida teniotis (Rafinesque, 1814)

FMaxE: 10–20 kHz; Fstart: 14–28 kHz; Fend: 8–18 kHz; Duration: 7–27 ms. Pulse with dominant narrowband QCF, sometimes containing a small initial FM component. Not always distinguishable from *Tadarida aegyptiaca* due to overlap in FMaxE between 14 and 20 kHz.

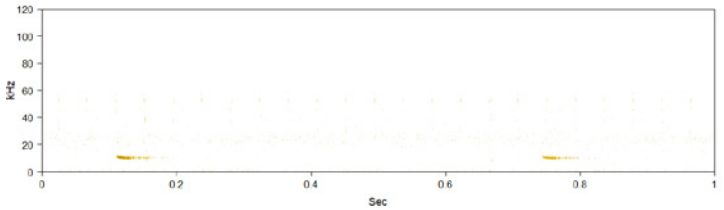


Figure 13 Sonogram depicting echolocation calls of *Tadarida teniotis.*

Naked-rumped Tomb Bat
Taphozous nudiventris (Cretzschmar, 1830)

FMaxE: 22–26 kHz; Fstart: 22–28 kHz; Fend: 20–24 kHz; Duration: 7–19.5 ms. Pulse with dominant narrowband QCF, sometimes containing a small initial FM component. Generally with harmonics present.

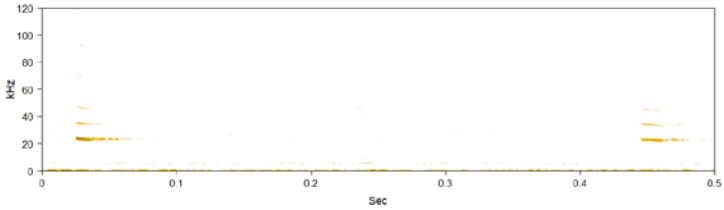


Figure 14 Sonogram depicting echolocation calls of *Taphozous nudiventris.*

Egyptian Slit-faced Bat
Nycteris thebaica (E. Geoffroy, 1818)

FMaxE: 68–91 kHz; Fstart: 75–83 kHz; Fend: 61–66 kHz; Duration: 1–3 ms. Pulse with only an FM component (extremely modulated pulses). Usually, weak pulses.

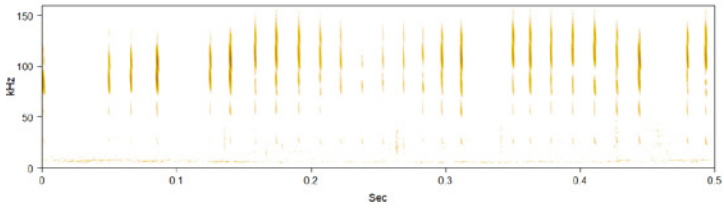


Figure 15 Sonogram depicting echolocation calls of *Nycteris thebaica.*

Arabian Barbastelle

Barbastella leucomelas (Cretzschmar, 1826)

FMaxE: 32–37 kHz; Fstart: 34–42 kHz; Fend: 22–35 kHz; Duration: 2–7 ms. Pulse with a short, narrowband FM with a final QCF component. Two types of pulses: main pulse as above (bottom pulse in sonogram) and second pulse weaker with a higher FMaxE (top pulse in sonogram).

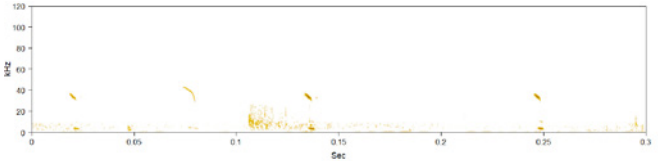


Figure 16 Sonogram depicting echolocation calls of *Barbastella leucomelas.*

Botta's Serotine

Cnephaeus bottae (Peters, 1869)

FMaxE: 29–37 kHz; Fstart: 38–56 kHz; Fend: 27–34 kHz; Duration: 2–10 ms. Pulse with a short, broadband FM with a final QCF component (very variable proportions of each type). Not always distinguishable from *Hypsugo ariel* and *Pipistrellus kuhlii* due to overlap in FMaxE between 33 and 37 kHz.

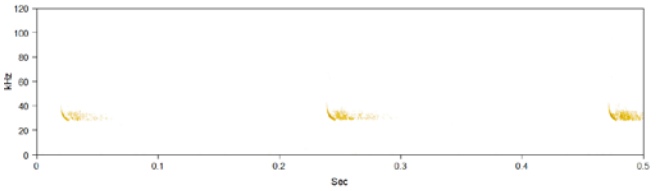


Figure 17 Sonogram depicting echolocation calls of *Cnephaeus bottae.*

Fairy Pipistrelle

Hypsugo ariel (Thomas, 1904)

FMaxE: 33–50 kHz; Fstart: 36–87 kHz; Fend: 28–48 kHz; Duration: 2–15 ms. Pulse with a short, broadband FM with a final QCF component (very variable proportions of each type). Not always distinguishable from *Cnephaeus bottae* due to overlap in FMaxE between 33 and 37 kHz and from *Pipistrellus kuhlii* due to overlap between 36 and 47 kHz.

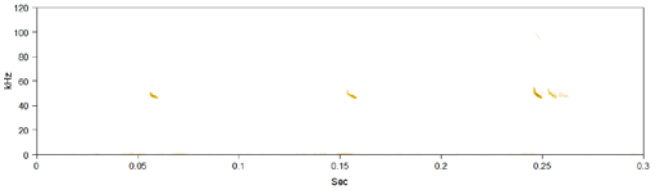


Figure 18 Sonogram depicting echolocation calls of *Hypsugo ariel.*

Geoffroy's Myotis
Myotis emarginatus (E. Geoffroy, 1806)

FMaxE: 45–79 kHz; Fstart: 73–121 kHz; Fend: 39–49 kHz; Duration: 1–5 ms. Pulse with only an FM component (extremely modulated pulses).

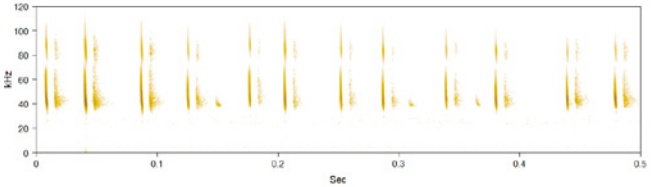


Figure 19 Sonogram depicting echolocation calls of *Myotis emarginatus.*

Desert Long-eared Bat
Otonycteris hemprichii (Peters, 1859)

FMaxE: 16–33 kHz; Fstart: 28–68 kHz; Fend: 15–26 kHz; Duration: 1–12 ms. Pulse with dominant broadband FM component, with harmonics always visible. Not always distinguishable from *Plecotus christii* due to overlap in FMaxE between 25 and 33 kHz.

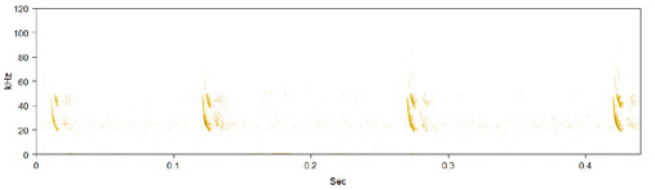


Figure 20 Sonogram depicting echolocation calls of *Otonycteris hemprichii.*

Kuhl's Pipistrelle
Pipistrellus kuhlii (Kuhl, 1817)

FMaxE: 36–47 kHz; Fstart: 39–67 kHz; Fend: 34–45 kHz; Duration: 2–13 ms. Pulse with a short, broadband FM with a final QCF component (very variable proportions of each type). Not always distinguishable from *Cnephaeus bottae* due to overlap in FMaxE between 36 and 37 kHz and from *Hypsugo ariel* due to overlap between 36 and 47 kHz.

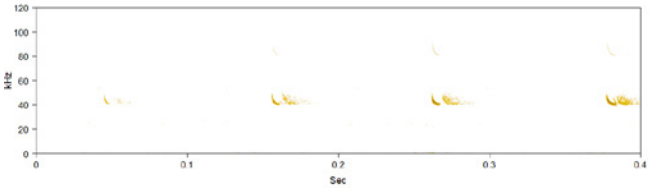


Figure 21 Sonogram depicting echolocation calls of *Pipistrellus kuhlii.*

Christie's Long-eared Bat
Plecotus christii (Gray, 1838)

FMaxE: 25–36 kHz; Fstart: 33–49 kHz; Fend: 20–27 kHz; Duration: 1–4 ms. Pulse with dominant broadband FM component, with harmonics always visible. Not always distinguishable from *Otonycteris hemprichii* due to overlap in FMaxE between 25 and 33 kHz.

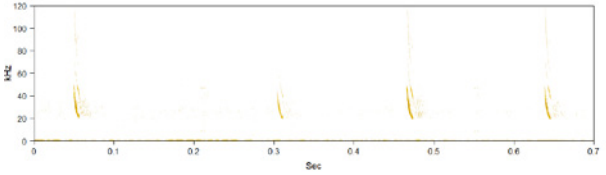


Figure 22 Sonogram depicting echolocation calls of *Plecotus christii.*

Arabian Mouse-tailed Bat
Rhinopoma cystops Thomas, 1903

FMaxE: 30–37 kHz; Fstart: 33–40 kHz; Fend: 29–36 kHz; Duration: 4–12 ms. Pulse with dominant narrowband QCF, sometimes containing a small initial FM component. Several harmonics are always visible (usually more than 4). FMaxE is usually present in the second harmonic. Not always distinguishable from *Rhinopoma microphyllum* due to overlap in FMaxE between 30 and 32 kHz.

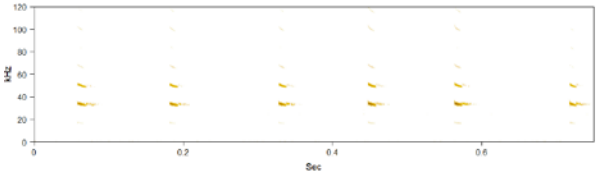


Figure 23 Sonogram depicting echolocation calls of *Rhinopoma cystops.*

Greater Mouse-tailed Bat
Rhinopoma microphyllum (E. Geoffroy, 1818)

FMaxE: 26–32 kHz; Fstart: 28–38 kHz; Fend: 23–31 kHz; Duration: 3–13 ms. Pulse with dominant narrowband QCF, sometimes containing a small initial FM component. Several harmonics are always visible (usually more than 4). FMaxE is usually present in the second harmonic. Not always distinguishable from *Rhinopoma cystops* due to overlap in FMaxE between 30 and 32 kHz.

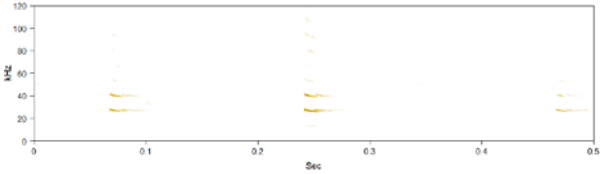


Figure 24 Sonogram depicting echolocation calls of *Rhinopoma microphyllum.*

Pallid Long-fingered Bat
Miniopterus pallidus (Thomas, 1907)

FMaxE: 52–58 kHz; Fstart: 58–61 kHz; Fend: 30–57 kHz; Duration: 4–6 ms. Pulse with a short, broadband FM with a final QCF component (very variable proportions of each type).

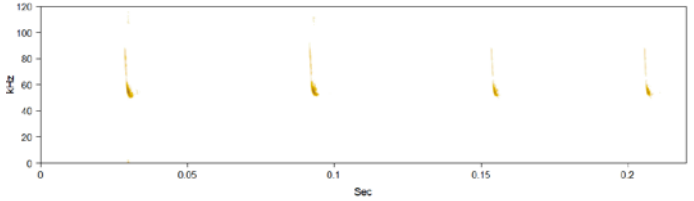


Figure 25 Sonogram depicting echolocation calls of *Miniopterus pallidus*.

Geoffroy's Horseshoe Bat
Rhinolophus clivosus (Cretzschmar, 1828)

FMaxE: 80–94 kHz; Fstart: 72–75 kHz; Fend: 62–90 kHz; Duration: 9–64 ms. Pulse with dominant CF component with narrowband FM component in the beginning and end (not always visible).

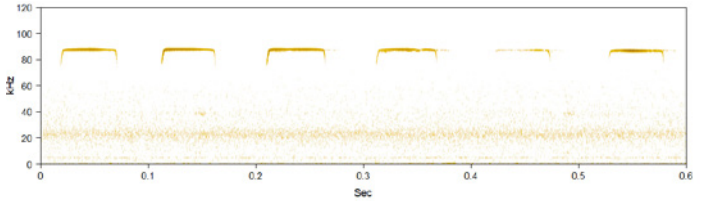


Figure 26 Sonogram depicting echolocation calls of *Rhinolophus clivosus*.

Lesser Horseshoe Bat
Rhinolophus hipposideros (Bechstein, 1800)

FMaxE: 101–111 kHz; Fstart: 80–112 kHz; Fend: 82–111 kHz; Duration: 30–61 ms. Pulse with dominant CF component with narrowband FM component in the beginning and end (not always visible).

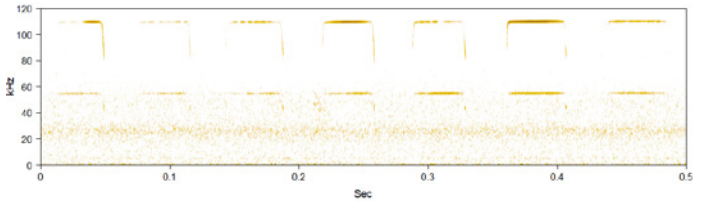


Figure 27 Sonogram depicting echolocation calls of *Rhinolophus hipposideros*.

11. Checklist of the Mammals of AlUla

Mammal Species		Conservation Status by IUCN	
Order\Family / Common name	Latin name	Global	Regional
Hyracoidea \ Procaviidae			
Rock Hyrax	*Procavia capensis*	LC	LC
Lagomorpha \ Leporidae			
Cape Hare	*Lepus capensis*	LC	NT
Rodentia \ Gliridae			
Black-tailed Garden Dormouse	*Eliomys melanurus*	LC	LC
Rodentia \ Dipodidae			
Arabian Jerboa	*Jaculus loftusi*	NE	NE
Rodentia \ Muridae			
Arabian Spiny Mouse	*Acomys dimidiatus*	LC	LC
Golden Spiny Mouse	*Acomys russatus*	LC	LC
Cheesman's Gerbil	*Gerbillus cheesmani*	LC	LC
Wagner's Gerbil	*Gerbillus dasyurus*	LC	LC
Balochistan Gerbil	*Gerbillus nanus*	LC	LC
Large Aden Gerbil	*Gerbillus poecilops*	LC	LC
Sundevall's Jird	*Meriones crassus*	LC	LC
House Mouse	*Mus musculus*	LC	NA
Fat Sand Rat	*Psammomys obesus*	LC	LC
Bushy-tailed Jird	*Sekeetamys calurus*	LC	LC
Eulipotyphla \ Soricidae			
Lesser White-toothed Shrew	*Crocidura suaveolens*	LC	LC
Eulipotyphla \ Erinaceidae			
Desert Hedgehog	*Paraechinus aethiopicus*	LC	LC
Chiroptera \ Pteropodidae			
Egyptian Rousette	*Rousettus aegyptiacus*	LC	LC
Chiroptera \ Hipposideridae			
Geoffroy's Trident Leaf-nosed Bat	*Asellia tridens*	LC	LC

Order\Family / Common name	Latin name	Global	Regional
Chiroptera \ Molossidae			
Egyptian Free-tailed Bat	*Tadarida aegyptiaca*	LC	DD
European Free-tailed Bat	*Tadarida teniotis*	LC	LC
Chiroptera \ Emballonuridae			
Naked-rumped Tomb Bat	*Taphozous nudiventris*	LC	LC
Chiroptera \ Nycteridae			
Egyptian Slit-faced Bat	*Nycteris thebaica*	LC	LC
Chiroptera \ Vespertilionidae			
Arabian Barbastelle	*Barbastella leucomelas*	LC	DD
Botta's Serotine	*Cnephaeus bottae*	LC	LC
Fairy Pipistrelle	*Hypsugo ariel*	DD	LC
Geoffroy's Myotis	*Myotis emarginatus*	LC	DD
Desert Long-eared Bat	*Otonycteris hemprichii*	LC	LC
Kuhl's Pipistrelle	*Pipistrellus kuhlii*	LC	LC
Christie's Long-eared Bat	*Plecotus christii*	DD	DD
Chiroptera \ Rhinopomatidae			
Arabian Mouse-tailed Bat	*Rhinopoma cystops*	LC	LC
Greater Mouse-tailed Bat	*Rhinopoma microphyllum*	LC	DD
Chiroptera \ Miniopteridae			
Pallid Long-fingered Bat	*Miniopterus pallidus*	NT	DD
Chiroptera \ Rhinolophidae			
Geoffroy's Horseshoe Bat	*Rhinolophus clivosus*	LC	LC
Lesser Horseshoe Bat	*Rhinolophus hipposideros*	LC	NT
Carnivora \ Canidae			
Grey Wolf	*Canis lupus*	LC	VU
Blanford's Fox	*Vulpes cana*	LC	VU
Red Fox	*Vulpes vulpes*	LC	LC
Carnivora \ Felidae			
Cheetah	*Acinonyx jubatus*	VU	RE
Caracal	*Caracal caracal*	LC	LC
Afro-Asiatic Wildcat	*Felis lybica*	LC	NT
Sand Cat	*Felis margarita*	LC	VU
Arabian Leopard	*Panthera pardus nimr*	VU	CR
Carnivora \ Hyaenidae			
Striped Hyena	*Hyaena hyaena*	NT	VU

Order\Family / Common name	Latin name	Global	Regional
Carnivora \ Mustelidae			
Honey Badger	*Mellivora capensis*	LC	NT
Cetartiodactyla \ Bovidae			
Nubian Ibex	*Capra nubiana*	VU	VU
Arabian Gazelle	*Gazella arabica*	VU	VU
Sand Gazelle	*Gazella marica*	VU	VU
Arabian Oryx	*Oryx leucoryx*	VU	VU

IUCN threat status for species globally and regionally.
Status: RE – Regionally Extinct; CR – Critically Endangered; VU – Vulnerable;
NT – Near Threatened; LC – Least Concern; DD – Data Deficient; NE – Not Evaluated;
NA – Not Applicable.

12. References

Abu Baker, M. & Amr, Z.S. (2003). Rodent diversity in the northeastern desert of Jordan, with special reference on the ecology of *Gerbillus cheesmani* (Mammalia: Rodentia). *Journal of the National Museum (Prague), Natural History Series* 172: 141–152.

Abu Baker, M.A., Buhadi, Y.A., Alenezi, A. & Amr, Z.S. (2022). Mammals of the State of Kuwait. IUCN, Gland (Switzerland); Environment Public Authority, Kuwait City (State of Kuwait).

ACR (2022). African Chiroptera Report 2022. Cakenberghe, V.V. & Seamark, E.C.J. (eds). pp. i–xvii + 8661. AfricanBats NPC, Pretoria (South Africa).

Al Obaid, A., Shuraim, F., Al Boug, A., Al Jbour, S., Neyaz, F., Aloufi, A.H. & Amr, Z. (2023). Diversity and conservation of bats in Saudi Arabia. *Diversity* 15: 700.

Al-Johany, A.M.H. (2007). Distribution and conservation of the Arabian Leopard *Panthera pardus nimr* in Saudi Arabia. *Journal of Arid Environments* 68: 20–30.

Alhajeri, B.H., Hasan, Z. & Alhaddad, H. (2023). Cranial differences in three-toed jerboas (Dipodinae, Dipodidae, Rodentia) according to recent taxonomic revisions. *Current Zoology* 69: 475–490.

Aloufi, A.A., Amr, Z.S. & Nassarat, H. (2016). Bats (Mammalia: Chiroptera) from Tabuk Province, Saudi Arabia. *Vertebrate Zoology* 66: 207–215.

Aloufi, A.A. & Amr, Z.S. (2018). Carnivores of the Tabuk Province, Saudi Arabia (Carnivora: Canidae, Felidae, Hyaenidae, Mustelidae). *Lynx* 49: 77–90.

Alqahtani, A.R.M. (2022). A survey of Carnivora diversity in Bisha district, southwestern Saudi Arabia. *Egyptian Academic Journal of Biological Sciences (B. Zoology)* 14: 295–307.

Amr, Z.S., Abu Baker, M., Qumsiyeh, M. & Eid, E. (2018). Systematics, distribution and ecological analysis of rodents in Jordan. *Zootaxa* 4397: 1–94.

Animal Diversity Web (2024). University of Michigan Museum of Zoology, Ann Arbor (Michigan, USA). https://animaldiversity.org/ [Accessed in February 2024].

Aspinall, S., Hellyer, P. & Drew, C. (2005). Terrestrial mammals. In: The Emirates: A natural history. Hellyer, P. & Aspinall, S. (eds). pp. 307–334. Trident Press, London (UK).

Atzeni, L., Ilany, A., Geffen, E., Cushman, S.A., Kaszta, Ż. & Macdonald D.W. (2024). Reviving the Arabian Leopard: Harnessing historical data to map habitat and pave the way for reintroduction. *Biological Conservation* 291: 110440.

Barari International Limited Company (2024). Baseline assessment – Wildlife reintroduction in Ashar. 2nd Deliverable Report. Barari International Limited Company, Riyadh (KSA).

Bärmann, E.V., Wronski, T., Lerp, H., Azanza, B., Börner, S., Erpenbeck, D., Rössner, G.E. & Wörheide, G. (2013). A morphometric and genetic framework for the genus *Gazella* de Blainville, 1816 (Ruminantia: Bovidae) with special focus on Arabian and Levantine mountain gazelles. *Zoological Journal of the Linnean Society* 169: 673–696.

Benda, P., Andreas, M., Kock, D., Lučan, R.K., Munclinger, P. et al. (2006). Bats (Mammalia: Chiroptera) of the Eastern Mediterranean. Part 4. Bat fauna of Syria: Distribution, systematics, ecology. *Acta Societatis Zoologicae Bohemicae* 70: 1–329.

Benda, P., Dietz, C., Andreas, M., Hotový, J., Lučan, R.K. et al. (2008). Bats (Mammalia: Chiroptera) of the Eastern Mediterranean and Middle East. Part 6. Bats of Sinai (Egypt) with some taxonomic, ecological and echolocation data on that fauna. *Acta Societatis Zoologicae Bohemicae* 72: 1–103.

Benda, P., Lučan, R.K., Obuch, J., Reiter, A., Andreas, M. et al. (2010). Bats (Mammalia: Chiroptera) of the Eastern Mediterranean and Middle East. Part 8. Bats of Jordan: Fauna, ecology, echolocation, ectoparasites. A*cta Societatis Zoologicae Bohemicae* 74: 185–353.

Benda, P., Vallo, P. & Reiter, A. (2011). Taxonomic revision of the genus *Asellia* (Chiroptera: Hipposideridae) with a description of a new species from southern Arabia. *Acta Chiropterologica* 13: 245–270.

Benda, P., Faizolâhi, K., Andreas, M., Obuch, J., Reiter, A. et al. (2012). Bats (Mammalia: Chiroptera) of the Eastern Mediterranean and Middle East. Part 10. Bat fauna of Iran. *Acta Societatis Zoologicae Bohemicae* 76: 163–582.

Benda, P., Nasher, A.K., Van Damme, K., Vallo, P. & Reiter, A. (2017). Bats (Mammalia: Chiroptera) of the Eastern Mediterranean and Middle East. Part 14. Bat fauna of the Socotra Archipelago, Yemen. *Acta Societatis Zoologicae Bohemicae* 81: 99–169.

Benda, P., Kasso, M., Nicolas, V., Pleurdeau, D., Stoetzel, E., Workalemahu, S., Bekele, A. & Denys, C. (2019). New data on bats from Dire Dawa region, eastern Ethiopia, with the first record of *Rhinopoma microphyllum* in the country. *Journal of Natural History* 53: 2579–2591.

Benda, P. & Mlíkovský, J. (2022). Nomenclatural notes on the Lesser Horseshoe Bat, *Rhinolophus hipposideros* (Mammalia: Chiroptera). *Journal of the National Museum (Prague), Natural History Series* 191: 5–14.

Berkovitz, B. & Shellis, P. (2018). The teeth of mammalian vertebrates. Academic Press (Elsevier), London (UK).

Blackburn, T.M. & Gaston, K.J. (1998). The distribution of mammal body masses. *Diversity and Distributions* 4: 121–133.

Boland, C.R.J. & Burwell, B.O. (2021). Ranking and mapping Saudi Arabia's high conservation priority terrestrial vertebrates. *Asian Journal of Conservation Biology* 10: 197–210.

Boug, A., Islam, M.Z.-u., Shehry, A.A. & Wronski, T. (2012). Camera trapping confirms the persistence of Arabian Gazelles, *Gazella arabica*, in the Asir Mountains, Saudi Arabia. *Zoology in the Middle East* 57: 3–10.

Bray, T.C., Mohammed, O.B., Butynski, T.M., Wronski, T., Sandouka, M.A. & Alagaili, A.N. (2014). Genetic variation and subspecific status of the Grey Wolf (*Canis lupus*) in Saudi Arabia. *Mammalian Biology*, 79: 409–413.

Breitenmoser, U., Breitenmoser-Würsten, C., von Arx, M. & Lanz, T. (2023). Cat Specialist Group Web Portal. *Cat Specialist Group* http://www.catsg.org/index.php?id=13 [Accessed in February 2024].

Brito, J.C., Godinho, R., Martínez-Freiría, F., Pleguezuelos, J.M., Rebelo, H. et al. (2014). Unravelling biodiversity, evolution and threats to conservation in the Sahara-Sahel. *Biological Reviews* 89: 215–231.

Brito, J.C. & Pleguezuelos, J.M. (2020). Desert biodiversity–World's hot spots/globally outstanding biodiverse deserts. In: Encyclopedia of the world's biomes, vol. 2. Goldstein, M.I. & Della Sala, D.A. (eds). pp. 10–22. Elsevier.

Brito, J.C., del Barrio, G., Stellmes, M., Pleguezuelos, J.M. & Saarinen, J. (2021). Drivers of change and conservation needs for vertebrates in drylands: An assessment from global scale to Sahara-Sahel wetlands. *European Zoological Journal* 88: 1103–1129.

Burgin, C.J., Colella, J.P., Kahn, P.L. & Upham, N.S. (2018) How many species of mammals are there? *Journal of Mammalogy* 99: 1–14.

Büttiker, W. & Krupp, F. (1985). Fauna of Saudi Arabia (Vol. 7). Pro Entomologia c/o Natural History Museum, Basel (Switzerland); Saudi Arabia Meteorology and Environmental Protection Administration, Riyadh (KSA).

Castelló, J.R. (2016). Bovids of the world: Antelopes, gazelles, cattle, goats, sheep, and relatives. Princeton University Press, Princeton (New Jersey, USA).

Castelló, J.R. (2018). Canids of the world: Wolves, wild dogs, foxes, jackals, coyotes, and their relatives. Princeton University Press, Princeton (New Jersey, USA).

Castelló, J.R. (2020). Felids and hyenas of the world: Wildcats, panthers, lynx, pumas, ocelots, caracals, and relatives. Princeton University Press, Princeton (New Jersey, USA).

Cunningham, P.L., & Wronski, T. (2010). Arabian wolf distribution update from Saudi Arabia. *Canid News* 13.1. https://www.canids.org/canidnews/13/Arabian_wolf_in_Saudi_Arabia.pdf

Cunningham, P.L. & Wronski, T. (2011). Sex ratios of Arabian Sand Gazelle *Gazella marica* Thomas, 1897 in the Mahazat as-Sayd Protected Area, Saudi Arabia. *Journal of Arid Environments* 75: 243–248.

Cunningham, P.L., Sandouka, M.A. & Wronski, T. (2011). Morphological characteristics and ageing criteria of Sand Gazelle (*Gazella subgutturosa marica Thomas*, 1897) and their use for wildlife management. *European Journal of Wildlife Research* 57: 865–872.

Czudek, R. (2006). Wildlife issues and development prospects in West and Central Asia: Thematic study for the Forestry Outlook Study for Africa. Wildlife Management Working Paper No. 9. FAO, Rome (Italy).

Darvish, J., Tarahomi, M., Dianat, M., Mohammadi, Z., Haddadian Shad, H. & Moshtaghi, S. (2016). Biosystematics of three-toed jerboas, genus *Jaculus* (Erxleben, 1777) (Dipodidae, Rodentia) from Iran. *Iranian Journal of Animal Biosystematics* 12: 123–139.

Dinerstein, E., Olson, D., Joshi, A., Vynne, C., Burgess, N.D. et al. (2017). An ecoregion-based approach to protecting half the terrestrial realm. *BioScience* 67: 534–545.

Dunford, C.E., Faure, J.P.B., Ross, M.D., Spalton, J.A., Drouilly, M. et al. (2023). Searching for spots: A comprehensive survey for the Arabian Leopard *Panthera pardus nimr* in Saudi Arabia. *Oryx*, 1–12.

Edwards, S., Al Awaj, M., Eid, E. & Attum, O. (2017). Mammalian activity at artificial water sources in Dana Biosphere Reserve, southern Jordan. *Journal of Arid Environments* 141: 52–55.

Eid, E., Abu Baker, M. & Amr, Z. (2020). National Red Data Book of mammals in Jordan. IUCN Regional Office for West Asia Amman, Amman (Jordan).

Feldhamer, G.A., Merritt, J.F., Krajewski, C., Rachlow, J.L. & Stewart, K.M. (2020). Adaptive radiation and diversity. In: Mammalogy: Adaptation, diversity, ecology. pp. 223–484. 5th edition. Johns Hopkins University Press, Baltimore (Maryland, USA).

Feldhamer, G.A., Merritt, J.F., Krajewski, C., Rachlow, J.L. & Stewart, K.M. (2020). Methods for studying mammals. In: Mammalogy: Adaptation, diversity, ecology. pp. 16–45. 5th edition. Johns Hopkins University Press, Baltimore (Maryland, USA).

GBIF.org (2022). GBIF Occurrence Download. Downloaded on 13 October 2022. https://doi.org/10.15468/dl.csm5ua

Gecchele, L.V., Bremner-Harrison, S., Gilbert, F., Soultan, A., Davison, A. & Durrant, K.L. (2017). A pilot study to survey the carnivore community in the hyper-arid environment of South Sinai mountains. *Journal of Arid Environments* 141: 16–24.

Goodman, S.M. & Ratrimomanarivo, F.H. (2007). The taxonomic status of *Chaerephon pumilus* from the western Seychelles: Resurrection of the name *C. pusillus* for an endemic species. *Acta Chiropterologica* 9: 391–399.

Green, A.A. (1986). Status of large mammals of northern Saudi Arabia. *Mammalia* 50: 483–493.

Gross, C. (1996). Terrestrial mammals. In: Natural Emirates: Wildlife and environment of the United Arab Emirates. Vine, P.J. & Al Abed, I. (eds). pp. 214–226. Trident Press, London (UK).

Gürler, Ş., Bozkaya, F., Özüt, D. & Durmuş, M. (2015). Some morphological characteristics and neonatal weights of reintroduced gazelle (*Gazella subgutturosa*) in Turkey. *Turkish Journal of Zoology* 39: 458–466.

Hackett, T.D., Holderied, M.W. & Korine, C. (2017). Echolocation call description of 15 species of Middle-Eastern desert dwelling insectivorous bats. *Bioacoustics* 26: 217–235.

Harrison, D.L. & Bates, P.J.J. (1991). The mammals of Arabia. 2nd edition. Harrison Zoological Museum, Sevenoaks (UK).

Heikkinen, R.K., Luoto, M.L., Araújo, M.B., Virkkala R., Thuiller, W. & Sykes, M.T. (2006). Methods and uncertainties in bioclimatic envelope modelling under climate change. *Progress in Physical Geography: Earth and Environment* 30: 751–777.

Hemami, M.-R., Khosravi, R., Groves, C. & Ahmadi, M. (2020). Morphological diversity and ecological niche divergence in Goitered and Sand Gazelles. *Ecology and Evolution* 10: 11535–11548.

Hetem, R.S., Strauss, W.M., Fick, L.G., Maloney, S.K., Meyer, L.C.R., Shobrak, M., Fuller, A. & Mitchell, D. (2010). Variation in the daily rhythm of body temperature of free-living Arabian Oryx (*Oryx leucoryx*): Does water limitation drive heterothermy? *Journal of Comparative Physiology B* 180: 1111–1119.

Hetem, R.S., Strauss, W.M., Fick, L.G., Maloney, S.K., Meyer, L.C.R., Shobrak, M., Fuller, A. & Mitchell, D. (2012). Activity re-assignment and microclimate selection of free-living Arabian Oryx: Responses that could minimise the effects of climate change on homeostasis? *Zoology* 115: 411–416.

Hetem, R.S., Strauss, W.M., Fick, L.G., Maloney, S.K., Meyer, L.C.R., Shobrak, M., Fuller, A. & Mitchell, D. (2012). Does size matter? Comparison of body temperature and activity of free-living Arabian Oryx (*Oryx leucoryx*) and the smaller Arabian Sand Gazelle (*Gazella subgutturosa marica*) in the Saudi desert. *Journal of Comparative Physiology B* 182: 437–449.

Hill, J. E. (1977). A review of the Rhinopomatidae (Mammalia: Chiroptera). *Bulletin of the British Museum (Natural History)* 32: 29–43.

Hoath, R. (2009). A field guide to the mammals of Egypt. 1st edition. The American University in Cairo Press, Cairo (Egypt).

Hoffmann, A., Decher, J., Rovero, F., Voigt, C. & Schaer, J. (2010). Field methods and techniques for monitoring mammals. In: Manual on field recording techniques and protocols for all taxa biodiversity inventories. Eymann, J., Degreef, J., Häuser, C., Monje, J.C., Samyn, Y. & VandenSpiegel, D. (eds). pp. 482–529. ABC Taxa, Brussels, Tervuren and Meise (Belgium).

Hoffmann, R.S., Wilson, D.E. & Reeder, D.M. (1993). Order Lagomorpha. In: Mammal species of the world. Wilson, D.E. & Reeder, D.M., (eds). pp. 807–827. 2nd edition. Smithsonian Institution Press, Washington (USA) and London (UK).

Holden, M.E., (1993). Order Rodentia – Family Myoxidae. In: Mammal species of the world. Wilson, D.E. & Reeder, D.M., (eds). pp. 763–770. 2nd edition. Smithsonian Institution Press, Washington (USA) and London (UK).

Wilson D. E. Reeder D. M. (eds.). 2005. Mammal Species of the World: A Taxonomic and Geographic Reference.3rd edition. Johns Hopkins University Press, Baltimore, Maryland (USA).

Hulva, P., Horáček, I. & Benda, P. (2007). Molecules, morphometrics and new fossils provide an integrated view of the evolutionary history of Rhinopomatidae (Mammalia: Chiroptera). *BMC Evolutionary Biology* 7: 165.

Hutterer, R. & Harrison, D. (1988). A new look at the shrews (Soricidae) of Arabia. *Bonner Zoologische Beiträge* 39: 59–72.

Iribarren, C. & Kotler, B.P. (2012). Foraging patterns of habitat use reveal landscape of fear of Nubian Ibex *Capra nubiana*. *Wildlife Biology* 18: 194–201.

Islam, M.M., Farag, E., Mahmoudi, A., Hassan, M.M., Atta, M., Mostafavi, E., Alnager, I.A., Farrag, H.A., Eljack, G.E.A. & Bansal, D. (2021). Morphometric study of *Mus musculus*, *Rattus norvegicus*, and *Rattus rattus* in Qatar. *Animals* 11: 2162.

IUCN (2023). The IUCN Red List of Threatened Species. Version 2023–1. https://www.iucnredlist.org [Accessed in February 2024].

Judas, J., Paillat, P., Khoja, A. & Boug, A. (2006). Status of the Arabian Leopard in Saudi Arabia. *CAT News* Special Issue 1 – Arabian Leopard: 11–19.

Karger, D.N., Conrad, O., Böhner, J., Kawohl, T., Kreft, H. et al. (2017). Climatologies at high resolution for the Earth land surface areas. *Scientific Data* 4: 170122.

Khayat, R.O., Dakhil, M.A. & Tolba, M. (2024). Precipitation seasonality determines the potential distribution of *Hyaena hyaena* in Saudi Arabia: Towards conservation planning. *Journal for Nature Conservation* 79: 126618.

Kingdon, J., Happold, D., Butynski, T., Hoffmann, M., Happold, M. & Kalina, J. (2013). Mammals of Africa (6 vols). Bloomsbury Publishing, London (UK).

Kitchener, A.C. et al. (2017). A revised taxonomy of the Felidae: The final report of the Cat Classification Task Force of the IUCN/SSC Cat Specialist Group. *CAT News* Special Issue 11.

KSA-Kingdom of Saudi Arabia (2020). Vision 2030. Kingdom of Saudi Arabia.

Lerp, H. (2014). The phylogeny of the genus *Gazella* and the phylogeography and population genetics of Arabian species. Johann Wolfgang Goethe University, Frankfurt am Main (Germany).

Mallon, D.P., Hilton-Taylor, C., Amori, G., Baldwin, R., Bradshaw, P.L. & Budd, K. (2023). The conservation status and distribution of the mammals of the

Arabian Peninsula. IUCN, Gland (Switzerland); Environment and Protected Areas Authority, Sharjah (UAE).

Mbogga, M.S., Wang, X. & Hamann, A. (2010). Bioclimate envelope model predictions for natural resource management: Dealing with uncertainty. *Journal of Applied Ecology* 47: 731–740.

Mensoor, M. (2023). The mammals of Yemen (Chordata: Mammalia). Preprint at https://doi.org/10.20944/preprints202301.0181.v1.

Mohamed, W.F. (2016). On the occurrence of Arabian Red Fox *Vulpes vulpes arabica* (Thomas, 1902) in Sakaka, northern Saudi Arabia. *Pakistan Journal of Zoology* 48: 1979–1982.

Mohammadi, S., Ebrahimi, E., Moghadam, M.S. & Bosso, L. (2019). Modelling current and future potential distributions of two desert jerboas under climate change in Iran. *Ecological Informatics* 52: 7–13.

Muir-Wright, M.T. (1999). The diet of the highly endangered Arabian Leopard (*Panthera pardus nimr*). University of Aberdeen, Aberdeen (UK).

Musser, G.G. & Carleton, M.D. (1993). Order Rodentia – Family Muridae. In: Mammal species of the world: A taxonomic and geographic reference. Wilson, D.E. & Reeder, D.M., (eds). pp. 501–755. 2nd edition. Smithsonian Institution Press, Washington (USA) and London (UK).

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B. & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature* 403: 853–858.

Nowak, R.M. (2018). Order Hyracoidea. In: Walker's mammals of the world. pp. 449–462. Johns Hopkins University Press, Baltimore (Maryland, USA).

Ostrowski, S. & Williams, J.B. (2006). Heterothermy of free-living Arabian Sand Gazelles (*Gazella subgutturosa marica*) in a desert environment. *Journal of Experimental Biology* 209: 1421–1429.

Paray, B.A. & Al-Sadoon, M.K. (2018). A survey of mammal diversity in the Turaif province, Kingdom of Saudi Arabia. *Saudi Journal of Biological Sciences* 25: 604–608.

Parrini, F., Cain, J.W. III & Krausman, P.R. (2009). *Capra ibex* (Artiodactyla: Bovidae). *Mammalian Species* 830: 1–12.

Riesch, R., Martin, R.A., Lerp, H., Plath, M. & Wronski, T. (2013). Size and sex matter: Reproductive biology and determinants of offspring survival in *Gazella marica*. *Biological Journal of the Linnean Society* 110: 116–127.

Russo, D. (2023). Chiroptera. Springer Nature, Berlin (Germany).

Sarli, J., Lutermann, H., Alagaili, A.N., Mohammed, O.B. & Bennett, N.C. (2016). Seasonal reproduction in the Arabian Spiny Mouse, *Acomys dimidiatus* (Rodentia: Muridae) from Saudi Arabia: The role of rainfall and temperature. *Journal of Arid Environments* 124: 352–359.

Schlitter, D. & Qumsiyeh, M. (1996). *Rhinopoma microphyllum*. *Mammalian Species* 542: 1–5.

Schulz, E., Fraas, S., Kaiser, T.M., Cunningham, P.L., Ismail, K. & Wronski, T. (2013). Food preferences and tooth wear in the Sand Gazelle (*Gazella marica*). *Mammalian Biology* 78: 55–62.

Seddon, P., van Heezik, Y. & Nader, I. (1997). Mammals of the Harrat al-Harrah Protected Area, Saudi Arabia. *Zoology in the Middle East* 14: 37–46.

Shalmon, B. (1986). Wolves in the southern Arava. *Re'em* 5: 60–74.

Shalmon, B., Sun, P. & Wronski, T. (2021). Early and late fawn mortality in a remnant population of Arabian Gazelles (*Gazella arabica*). *Mammalian Biology* 101: 709–714.

Space for Giants (2022). Wadi Nakhlah – Ecological Strategies [Ecology Baseline and Associated Annexures]. Report from Space for Giants.

Streicher, S., Lutermann, H., Bennett, N.C., Bertelsen, M.F., Mohammed, O.B. et al. (2017). Living on the edge: Daily, seasonal and annual body temperature patterns of Arabian Oryx in Saudi Arabia. *PLoS ONE* 12: e0180269.

Stuart, C. & Stuart, T. (2016). Mammals of North Africa and the Middle East. 2nd edition. Bloomsbury Natural History, London (UK).

Thouless, C.R., Grainger, J.G., Shobrak, M. & Habibi, K. (1991). Conservation status of gazelles in Saudi Arabia. *Biological Conservation* 58: 85–98.

Vanderhaar, J.M. & Hwang, Y.T. (2003). *Mellivora capensis*. *Mammalian Species* 721: 1–8.

von Jaffa, N.A.B.K.P.S. (2020). The Arabian Striped Hyaena (*Hyaena hyaena sultana* Pocock, 1934) in the Kingdom of Saudi Arabia. *Gazelle: The Palestinian Biological Bulletin* 185: 1–38.

Wacher, T., Wronski, T., Hammond, R.L., Winney, B., Blacket, M.J. et al. (2011). Phylogenetic analysis of mitochondrial DNA sequences reveals polyphyly in the Goitred Gazelle (*Gazella subgutturosa*). *Conservation Genetics* 12: 827–831.

Weather Spark (2023). Climate and Average Weather Year Round in Al-ʿUla, Saudi Arabia. https://weatherspark.com/y/100173/Average-Weather-in-Al-%60Ula-Saudi-Arabia-Year-Round

Wilson, D.E. & Mittermeier, R.A. (2009). Handbook of the mammals of the world – Volume 1: Carnivores. 1st edition. Lynx Edicions, Barcelona (Spain).

Wilson, D.E. & Mittermeier, R.A. (2011). Handbook of the mammals of the world – Volume 2: Hoofed mammals. 1st edition. Lynx Edicions, Barcelona (Spain).

Wilson, D.E. & Mittermeier, R.A. (2018). Handbook of the mammals of the world – Volume 8: Insectivores, sloths and colugos. 1st edition. Lynx Nature Books, Barcelona (Spain).

Wilson, D.E., Thomas, E., Lacher, T.E. & Mittermeier, R.A. (2016). Handbook of the mammals of the world – Volume 6: Lagomorphs and rodents I. 1st edition. Lynx Nature Books, Barcelona (Spain).

Wilson, D.E., Thomas, E., Lacher, T.E. & Mittermeier, R.A. (2017). Handbook of the mammals of the world – Volume 7: Rodents II. 1st edition. Lynx Nature Books, Barcelona (Spain).

Wronski, T. & Macasero, W. (2008). Evidence for the persistence of Arabian Wolf (*Canis lupus pallipes*) in the Ibex Reserve, Saudi Arabia and its preferred prey species. *Zoology in the Middle East* 45: 11–18.

Wronski, T., Sandouka, M., Plath, M. & Cunningham, P. (2010). Differences in sexual dimorphism among four gazelle taxa (*Gazella* spp.) in the Middle East. *Animal Biology* 60: 395–412.

Wronski, T., Apio, A., Plath, M. & Ziege, M. (2013). Sex difference in the communicatory significance of localized defecation sites in Arabian Gazelles (*Gazella arabica*). *Journal of Ethology* 31: 129–140.

WTO-World Tourism Organization (2020). AlUla Framework for Inclusive Community Development through Tourism. UNWTO, Madrid (Spain).

Yousefi, M., Mahmoudi, A., Kafash, A., Khani, A. & Kryštufek, B. (2022). Biogeography of rodents in Iran: Species richness, elevational distribution, and their environmental correlates. *Mammalia* 86: 309–320.

Yusefi, G.H., Faizolahi, K., Darvish, J., Safi, K. & Brito, J.C. (2019). The species diversity, distribution, and conservation status of the terrestrial mammals of Iran. *Journal of Mammalogy* 100: 55–71.

Zafar-ul Islam, M., Boug, A., Judas, J. & As-Shehri, A. (2018). Conservation challenges for the Arabian Leopard (*Panthera pardus nimr*) in the western highlands of Arabia. *Biodiversity* 19: 188–197.

Zafar-ul Islam, M., Boug, A., Shehri, A. & Gonçalves da Silva, L. (2019). Geographic distribution patterns of melanistic Arabian wolves, *Canis lupus arabs* (Pocock), in Saudi Arabia. *Zoology in the Middle East* 65: 95–103.

Zhang, X., Liu, L., Chen, X., Gao, Y., Xie S. & Mi, J. (2021). GLC_FCS30: Global land-cover product with fine classification system at 30 m using time-series Landsat imagery. *Earth System Science Data* 13: 2753–2776.

13. Index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