THE BIRDS OF SAUDI ARABIA

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The Birds of Saudi Arabia

CHRIS BOLAND AND ABDULLAH ALSUHAIBANY

VOLUME 1: THE LIVES OF BIRDS

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Foreword

IT IS WITH GREAT delight that we bring you *The Birds of Saudi Arabia* – the first book dedicated to birds here in the Kingdom.

As a young boy growing up in the Eastern Province, I was fascinated by the variety of birds that would pass through our neighborhood each year. My family and I found these birds captivating. Over time we learned their names and enjoyed watching the many social interactions that birds have every day – but how we would have appreciated a book such as this to help us find out so much more about these feathered creatures.

This beautiful book focuses on the unique birds of the Arabian Peninsula. It also highlights the challenges resident birds must overcome to nest in Saudi Arabia, and the dangers that migratory birds face as they pass through the Kingdom. It discusses the significant role of birds in Arabian cultural history, and considers their potential status in the future. I believe it will stand as a key reference on this subject for years to come.

Not only is the book highly informative, it is also inspiring. It is filled with one thousand remarkable bird photographs taken by some of Saudi Arabia's best wildlife photographers – breathtaking portraits that help capture the exceptional diversity, beauty, grace, charm, and vulnerabilities of the birds of Saudi Arabia.

More than anything, this wonderful book reminds us how fortunate we are to share this land with such a wide variety of truly special birds.

AMIN H. NASSER
PRESIDENT AND CEO
SAUDI ARAMCO

CORN BUNTING

Preface

THE BIRDS OF SAUDI ARABIA are extraordinary. In total, 499 species have been recorded in the Kingdom. This incredible diversity includes some of the most beautiful birds on earth, some of the most fascinating, some of the most bizarre, some of the most migratory, some of the rarest, some of the smallest, some of the largest, and some of the fastest birds on earth. Indeed, the birds of Saudi Arabia should be world famous.

Because of Saudi Arabia's central location between Africa, India, Europe and Asia, an eclectic array of birds occurs in the Kingdom. Saudi Arabia hosts bird species that originated in Africa (such as Abyssinian Roller, African Paradise-flycatcher, Egyptian Vulture, and Nile Valley Sunbird), as well as birds from Europe, (such as Cyprus Wheatear, European Robin, Mediterranean Gull, and Spanish Sparrow), birds from the Middle East (including Basra Reed-warbler, Kurdish Wheatear, Levant Sparrowhawk, and Palestine Sunbird), birds from Asia, (Caspian Plover, Indian Silverbill, Oriental Skylark, and Siberian Chiffchaff), and birds from even farther afield (such as Arctic Jaeger, Pacific Golden Plover, and Northern Wheatear). Many of the birds that migrate to or through Saudi Arabia will have nested as far away as Sri Lanka, South Africa, Norway, Iceland, Georgia, Siberia, Alaska, and even Canada. A further 46 species fly to Saudi Arabia each year to breed, with most arriving from Africa or India.

Saudi Arabia also contains 19 species that are largely or entirely confined to the Arabian Peninsula, including the dazzling Arabian Sunbird, the astonishing Arabian Babbler, the enigmatic Arabian Scops-owl, the rare Arabian Grosbeak, and the quizzical Arabian Woodpecker. One endemic species, the Asir Magpie, is confined entirely to Saudi Arabia, occurring only in a few small patches in the 'Asir Mountains. This highly endangered bird, which has a fair claim to being the National Bird of Saudi Arabia, is one of the rarest birds on the planet.

What's more, the birds of Saudi Arabia are living in perhaps the most punishing conditions on earth. The majority of the Kingdom experiences a desert climate characterized by extreme heat and negligible rainfall. The average daily summer maximum temperature is about 45°C, but temperatures of up to 54°C can occur. The heat becomes intense shortly after sunrise and persists until well after sunset. Desiccating northerly winds (known locally as *shamal*) can bring severe sand storms that make flying and foraging impossible. In winter, air temperature can drop below freezing, particularly in the precipitous mountains of the west. For most of the Kingdom, annual rainfall is very low and highly erratic. The entire year's rainfall may consist of one or two heavy downpours or thunderstorms. Some parts of the Rub' al-Khali may not receive any rain for a decade. Not one drop. And yet, every year an estimated 27 million pairs of birds attempt to breed in Saudi Arabia. Millions more migrate to spend the winter here or to pass through the Kingdom on their epic journeys to more distant lands. Every one of those birds is a living marvel, a portrait of perseverance. Every one of those birds relies upon the people of Saudi Arabia to grant them safe passage.


SOOTY GULL

Is it any wonder then that birds have been a central part of Arabian culture for as long as humans have lived in Arabia? Their colorful plumage, their sweet song, their dogged fortitude, and their beguiling behavior has captivated the hearts of the people of Arabia for centuries, indeed millennia. Birds have pervaded Arabic art, poetry, folklore, and song. They are used as enduring symbols of love, peace, strength, and gentleness. They are mentioned in the Qur'an on 20 occasions, where they teach lessons of courage and faith, and demonstrate the grace of god through their mastery of flight.

This book is a celebration of these extraordinary birds. We celebrate the importance of birds in Arabian culture (Chapter 2); we celebrate the diversity of birds across the various ecosystems of Saudi Arabia (Chapter 3); we celebrate the birds that are able to overcome the extreme challenges of breeding in this hyper-arid environment (Chapter 4); we celebrate the birds that migrate vast distances to visit the Kingdom (Chapter 5); we celebrate the birds that are endemic to the Arabian Peninsula (Chapter 6); and we celebrate the exceptional diversity of birds that share this land with us (Volume 2). We begin by discussing the status of the Kingdom's birds (Chapter 1), noting the significant changes that are right now taking place in the distribution and abundance of the birds of Saudi Arabia.

One of the themes of this book is that very few in-depth studies have been conducted on birds within the Kingdom. This is a great shame as the birds of Saudi Arabia are remarkable and their stories deserve to be told. We hope this book helps to inform people that the birds of this Kingdom are indeed extraordinary and we hope to inspire people to enjoy, to learn about, to study, to cherish, and most of all to protect the birds of Saudi Arabia.

CHRIS BOLAND AND
ABDULLAH ALSUHAIBANY

DIEDERIK CUCKOO

Acknowledgments

SAUDI ARABIAN photographers took the vast majority of photographs used in this book. In total, we received over 57,000 photographs from 55 Saudi Arabian photographers, both men and women, as well as 11 expatriate photographers living in Saudi Arabia. Overall, around 90% of the photos used in this book were taken within the Kingdom, with Saudi Aramco employees contributing about 20% of all photos used. A further 76 other photographers generously provided the remaining photographs, which were taken in Bahrain, Kuwait, Oman, UAE and, where necessary, from further afield.

The text and maps in the book were developed with contributions from the leading ornithologists in Saudi Arabia, including Jem Babbington and Philip Roberts (Saudi Aramco), Prof. Mohammad Shobrak (Tayif University), Dr. Ahmed al-Boug (Saudi Wildlife Authority), Michael Jennings and Peter Castell (Environmental Balance Establishment, Jiddah). Dr. Robert Sheldon (Chair of the Ornithological Society of the Middle East, the Caucasus and Central Asia), Sarah Alsaidalani, Sara Al-Bassam, Janet Pinheiro (Saudi Aramco) and Wendy Boland improved earlier drafts of this book. Bruce Burwell, Karim Hussein (Saudi Aramco), Osama Qurban and Mohammed Bukhari (Environmental Balance Establishment, Jiddah) conducted the GIS work required to produce the maps used in the book. Essam Mohamed provided the English translations of Arabic poetry in Chapter 2 unless otherwise stated. Aswathy Sathish, Noelandro de la Peña and Malda Smadi (Motivate Media Group) provided graphic design and publishing services.

We are grateful to Saudi Aramco for its unwavering support for this book, and for the Company's ongoing efforts in protecting and enhancing the birds of Saudi Arabia.

COMMON KINGFISHER

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Guide to Volume 1

CHECKLIST OF THE BIRDS OF SAUDI ARABIA

To date, there is no official checklist of the birds of Saudi Arabia. For this book, we have collated the expert knowledge and observations of the leading ornithologists and bird photographers of Saudi Arabia to develop a comprehensive checklist containing 412 regularly occurring species (including 11 exotic species) and 87 vagrant species. Thus 499 bird species have been recorded with confidence in the Kingdom. We believe that this is the most precise checklist of the birds of Saudi Arabia ever assembled (Appendix 1).

SPECIES NAMES AND TAXONOMY

The common and scientific names used throughout the book are based on the taxonomic system used by BirdLife International, the International Union for Conservation of Nature (IUCN), and the *Handbook of the Birds of the World*. By convention, official bird names are presented in British English, while the rest of the book is in American English as per the conventions of Saudi Aramco. Scientific names for other taxa mentioned in the book are included in Appendix 2.

CONSERVATION STATUS AND POPULATION TRENDS

Global conservation statuses and population trends are from the *IUCN Red List of Threatened Species*[1] and are up to date as of 10 March 2020. Regional conservation statuses and population trends are also from the IUCN's *Conservation Status and Distribution of the Breeding Birds of the Arabian Peninsula*[2] with updates from the *IUCN Red List of Threatened Species*[3] where applicable. Note that this regional assessment includes the Sinai Peninsula and areas north to Syria, Iraq and Kuwait.[4]

POPULATION SIZE ESTIMATES

Data on estimated annual breeding population sizes are primarily from the *Atlas of the Breeding Birds of Arabia*[5] with updates from our own records or more recent published accounts where applicable. *The Atlas of the Breeding Birds of Arabia* estimates are extrapolations based on survey data compiled from over 66,000 records across the Arabian Peninsula. While some of the estimates are based on inconsistent sampling and thus likely to be inaccurate, they nonetheless represent the best attempt to quantify the population sizes of the breeding birds of Saudi Arabia. The only deviations from the population estimates provided in the *Atlas of the Breeding Birds of Arabia* are for Arabian Lark, Asir Magpie, Egyptian Vulture, Grey Francolin, and Lanner Falcon, based on the lack of recent records for these species. Although specific numbers are given for annual breeding pairs, these should be regarded as broad estimates with wide error bars.

WESTERN REEF-EGRET

SIZE, WEIGHT AND WINGSPAN ESTIMATES

Body size, weight and wingspan measurements are based on data provided in the *Handbook of the Birds of the World*[6], with updates from our own records where applicable. In any analyses using body mass or body size, the mean of male and female weight or height is used.

FIGURES AND DATA ANALYSES

All figures and data analyses in this volume are based on the data presented in Volume 2 unless otherwise stated.

RANGE MAPS

The Saudi Arabian components of the endemic species range maps in Chapter 6 are from Volume 2 clipped to each species elevation range limits. The non-Saudi Arabian ranges are modified from *Handbook of the Birds of the World* again clipped to each species elevation range limits.

DATA SOURCES USED IN THIS BOOK

Over 700 scientific manuscripts and books were used in developing this book. These are listed in the References sections at the end of each volume. For more general information about the birds of Saudi Arabia, we frequently use and highly recommend the following key sources:

- *Atlas of the Breeding Birds of Arabia:* Jennings (2010)
- *BirdLife International:* www.birdlife.org
- *Birds of Saudi Arabia:* www.birdsofsaudiarabia.com
- *Handbook of the Birds of the World:* www.hbw.com
- *The IUCN Red List of Threatened Species:* www.iucnredlist.org
- *Ornithological Society of the Middle East, the Caucasus and Central Asia:* www.osme.org

BROWN BOOBY

PALESTINE SUNBIRD

The Birdwatcher's Code

IN ORDER TO ensure that bird-watching and bird photography is sustainable, it is essential that all bird-watchers and nature lovers adhere to the following simple principles:

1. **We always give the highest priority to the welfare of the bird.** Animal welfare always (*always*) comes first.
2. **We do not harass a bird to get a better view.** Harassing birds causes them stress and harm. We never rush up on a bird to make it fly or flush a bird from a bush just for a photograph. Flight is energetically expensive. Making a bird fly unnecessarily is stressing that bird. Birds that are gaping (that is, holding their mouth wide open) are already showing signs of heat stress. Thus harassing them significantly increases their chances of dying.
3. **We do not disturb breeding birds at the nest.** Even minimal disturbance can result in the nest, eggs and chicks being abandoned. For example, flushing a bird from the nest can cause egg temperature to increase above the lethal limit, ruining that year's nesting attempt (most birds only get a few breeding attempts in their life). If parents are unable to feed their chicks for even a short amount of time, then the chicks may die or fledge at a lighter weight making them unlikely to survive their first winter.
4. **We do not modify habitat around the nest.** Birds try to choose the optimal location for their nest that balances shelter, accessibility, and protection from predators. Thus modifying vegetation around the nest can expose the nest to too much sun or wind, or reveal its location to predators with fatal consequences. Repeatedly walking to a nest can leave both a foot trail and a scent trail for predators such as foxes, cats, and dogs to follow. There are no circumstances where it is acceptable to modify the nest or its approaches.
5. **We do not disturb endangered species.** By definition, endangered species are rare and usually decreasing in number. It is absolutely essential that we do not add any additional stresses to their fragile existence. By all means, find these birds, watch them, photograph them, admire them, wish them well, and then leave them alone. Endangered species are highlighted in the species accounts in this book.
6. **We do not disturb migratory birds.** Most migratory birds have already flown thousands of kilometers to arrive in Saudi Arabia and may be extremely tired and in urgent need of food and rest before resuming their long journeys. Many of these birds are on the brink of exhaustion. Disturbing them can kill them.
7. **We do not disturb wetland birds.** Wetland birds are notoriously vulnerable to disturbance. Enjoy them from a distance with binoculars or a spotting scope, and use a bird hide or take advantage of natural cover when watching them.

8. **We do not disturb owls and nightjars.** We do not flush an owl from its daytime roost. Owl eyesight is wonderfully adapted to nocturnal vision, but not for diurnal vision. If we are lucky enough to find an owl during the daytime, we observe them and photograph them and then leave them be. We regard watching and photographing owls at night as an enjoyable challenge that tests and extends our skills.
9. **We use spotlights sparingly.** We keep the bird held in the spotlight for seconds rather than minutes. Spotlighting disturbs birds and animals that are sleeping or resting and interferes with the vision of nocturnal species. Using a spotlight near a nest may also cause birds to abandon their nest or the young to fall.
10. **We always move quietly and slowly to avoid disturbing the birds.** Wherever possible, try to stay on paths and tracks to avoid damaging the habitats used by birds.
11. **We do not repeatedly play recordings of birdsong or calls.** Although it is tempting to repeatedly play bird calls to help get that perfect view or photograph, this will distract a territorial bird from other more important activities such as foraging, displaying, defending its territory or feeding its young. Most birds have barely enough time in each day for these essential activities. They cannot afford to spend additional energy chasing imaginary birds off their territory. Playing recordings should never be used to attract birds during their breeding season as this can cause a bird to abandon its nest.
12. **We always take all our litter away with us to be disposed of properly.** Where facilities exist we recycle as much of the rubbish as possible. When we go bird-watching we are guests in the habitats on which the birds depend for their very survival. Therefore, it is imperative that we minimize our impact on their habitat.

Accordingly, in this book we have only included photographs that have followed the principles outlined above. We only include photographs of nests that have not been disturbed. We do not include photographs of eggs or nestlings without their parents in attendance. There are no photographs of owls that have been flushed from their daytime roosts. We do not have photographs of birds that have been stressed by the photographer. We simply have photographs of birds in their natural habitats behaving naturally.

NILE VALLEY SUNBIRD

ENDEMIC TO SAUDI ARABIA, THE ASIR MAGPIE STANDS ON THE EDGE OF EXTINCTION.

CHAPTER 1

The Diversity and Status of the Birds of Saudi Arabia

KEY POINTS

- 499 bird species have been recorded in Saudi Arabia.
- 401 native or migratory species and 11 exotic species occur regularly in Saudi Arabia, while a further 87 species occur as vagrants.
- 19 species are endemic or nearly endemic to Arabia.
- 219 species breed in the Kingdom.
- 23% of all breeding species contain less than 100 annual breeding pairs.
- 25% of Saudi Arabia's birds are increasing, while 21% are decreasing.
- Increasing species usually occur in artificial habitats, whereas decreasing species usually occur in more natural habitats.
- Larger birds tend to be decreasing more rapidly than smaller birds.
- 29 species are regionally threatened, and 17 species are globally threatened.
- Four species may be locally extinct, while two more are on the verge of local extinction.

THE PIED KINGFISHER IS ONE OF 499 DIFFERENT SPECIES OF BIRD THAT HAVE BEEN RECORDED IN SAUDI ARABIA.

THE SURPRISING DIVERSITY OF BIRDS IN SAUDI ARABIA

A surprisingly high number of birds occur in Saudi Arabia. Indeed, according to our research, 499 bird species have been recorded with certainty in the Kingdom (*see* Table 1). At least 401 species occur naturally within the Kingdom (as native residents or frequent migratory species), along with 11 exotic species, while a further 87 species have been recorded on less than 10 occasions and are thus currently regarded as vagrants (*see* Volume 2). This number continues to grow as more bird observers identify and report rare birds from the many remote regions of this remarkable country.

As shown in Figure 1, birds can be found all over Saudi Arabia. By superimposing the range maps of every bird species (*see* Volume 2), we have created a 'heat map' of bird diversity across the Kingdom. Locations with more species are depicted in redder colors, whereas locations with fewer species are shown in greener colors. The greatest diversity of birds can be found around the coasts, around Riyadh (due to the presence of treated wastewater streams and surrounding farmlands), in the southwestern highlands, and in patches throughout the central deserts. Obviously the great aridity of the Rub' al-Khali results in fewer bird species – but even there up to 145 species (primarily passage migrants) could potentially be found throughout the year.

While 401 regular native or migratory species make an impressive bird list, how does that figure

TABLE 1: THE DIVERSITY OF SAUDI ARABIA'S BREEDING AND NON-BREEDING BIRD SPECIES.

BREEDING SPECIES	
NATIVE BREEDING RESIDENTS	162
NON-NATIVE BREEDING RESIDENTS	11
BREEDING MIGRANTS	46
	219
NON-BREEDING SPECIES	
WINTER VISITORS	52
PASSAGE MIGRANTS	49
WINTER VISITORS AND PASSAGE MIGRANTS	88
YEAR-ROUND VISITORS	4
VAGRANTS	87
	280
TOTAL	**499**

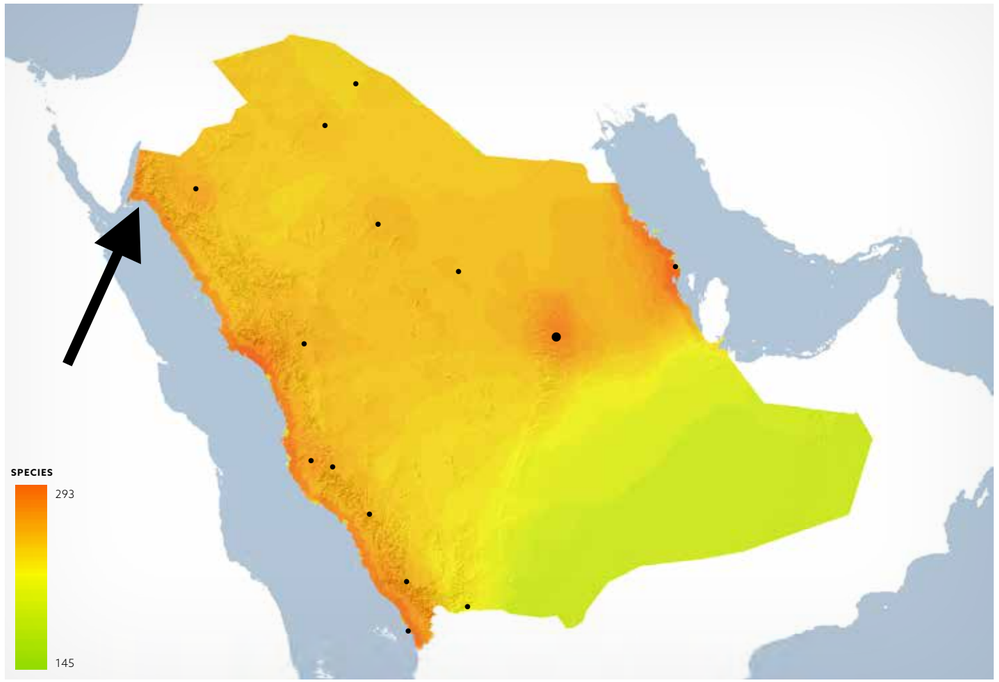


FIGURE 1: HEAT MAP OF BIRD DIVERSITY WITHIN SAUDI ARABIA[1]. REDDER COLORS INDICATE LOCATIONS WITH GREATER SPECIES DIVERSITY. GREENER COLORS INDICATE LOCATIONS WITH FEWER BIRD SPECIES. THE MINIMUM NUMBER OF BIRD SPECIES POTENTIALLY FOUND AT ANY LOCATION IN SAUDI ARABIA IS 145 IN THE RUB' AL-KHALI, WHILE THE MAXIMUM IS 293 IN THE 'ASIR MOUNTAINS.

THE RARE NORTHERN LONG-EARED OWL IS ONE OF AT LEAST 87 SPECIES THAT ARE VAGRANT TO SAUDI ARABIA.

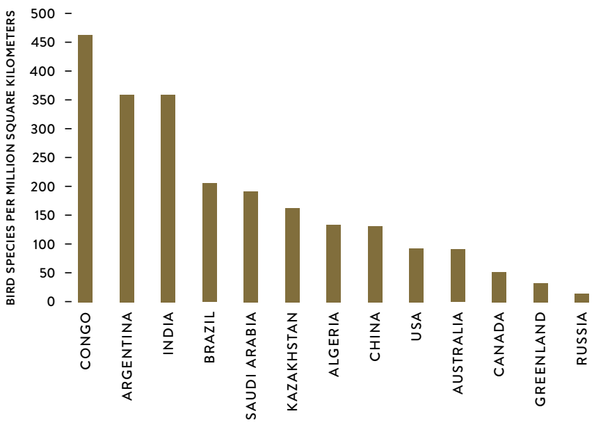


FIGURE 2: RELATIVE BIRD SPECIES DIVERSITY IN THE 13 LARGEST COUNTRIES ON EARTH.

Relative diversity is measured as the area of each country divided by the number of birds regularly recorded in the country multiplied by 1 million, which equates to the number of bird species per million square kilometers. Bird diversity data for the other 12 countries are from BirdLife International (2019b).

compare to other countries? After all, with an area of 2,149,690 square kilometers, the Kingdom of Saudi Arabia is one of the largest countries on earth – therefore, we might expect there to be a considerable diversity of birds within such a large landmass. Accordingly, Figure 2 plots the number of bird species regularly recorded within the world's largest countries divided by the overall area of each country to give a measure of relative bird diversity. This figure shows that while Saudi Arabia does not have as many birds as some other countries, particularly large tropical countries like India, Argentina and the Democratic Republic of Congo, it nonetheless has more bird species per square kilometer than countries such as Australia and the USA and almost as many species per unit of area as Brazil. In other words, while Saudi Arabia may be largely a desert, it is certainly not deserted. It has a rich and wonderful bird fauna (and an equally rich assemblage of reptiles, mammals, and plants too).

HAMERKOP BELONGS TO THE ORDER OF BIRDS CALLED PELECANIFORMES. SAUDI ARABIA CONTAINS 25 OF THE WORLD'S 36 DIFFERENT ORDERS OF BIRDS.

WHY ARE THERE SO MANY BIRDS IN SAUDI ARABIA?

A staggering 499 species of birds have been recorded in Saudi Arabia.

The striking diversity of birds recorded in Saudi Arabia is largely a result of global biogeography. The Arabian Peninsula lies at the crossroads of Africa, Europe, Asia, and the Indian subcontinent. Species from these surrounding landmasses have naturally colonized the Arabian Peninsula throughout the millennia and continue to do so. Consequently, if we travel to the west and southwest we find a large number of birds with Afrotropical origins; if we move north and northeast we find more Eurasian-Palearctic birds, and as we travel east and southeast we find more Indo-Malay birds (*see* Figure 3). This is well illustrated by the three colorful species of rollers that occur in Saudi Arabia. The Abyssinian Roller (which originated in the Afrotropical region) occurs in the southwest of the Kingdom, the Indian Roller (which is from the Indo-Malay region) occurs mainly in the Eastern Province, while the European Roller is widespread when migrating from the north.

Furthermore, Saudi Arabia is able to support a wide variety of birds because the Kingdom itself is composed of a diversity of ecosystem types, ranging from hyper-arid desert to relatively moist alpine areas, and from coral islands to vast rocky plains. Each ecosystem type hosts a different assemblage of birds that specialize in that particular ecosystem, resulting in an eclectic array of species across the Kingdom (*see* Chapter 3).

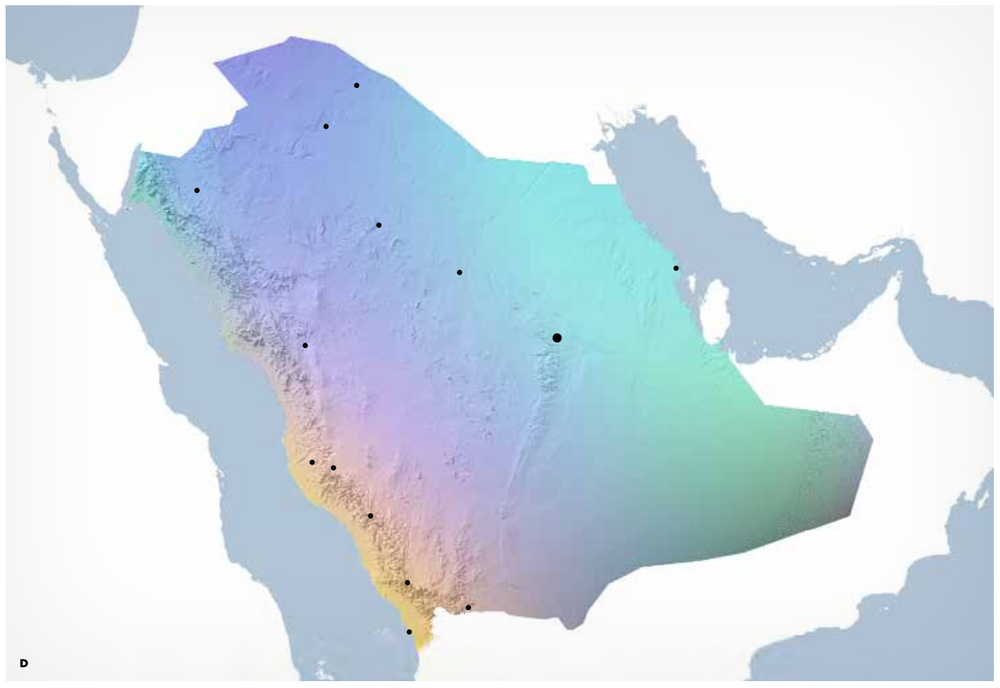
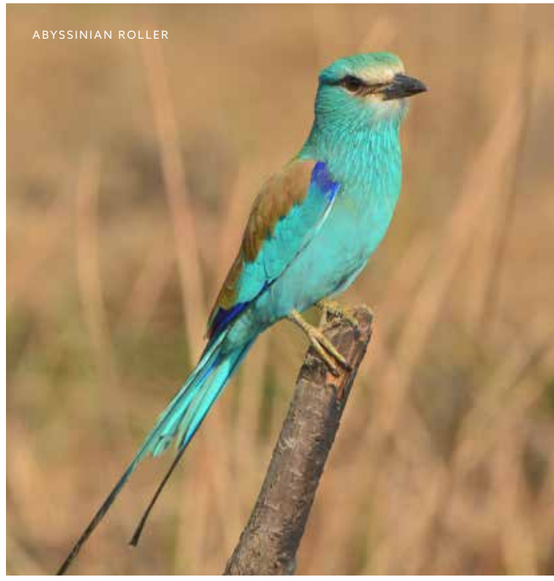


FIGURE 3: THE INFLUENCE OF GLOBAL BIOGEOGRAPHY ON THE BIRDS OF SAUDI ARABIA. DARKER COLORS INDICATE GREATER SPECIES DIVERSITY. (A) BIRDS WITH AFRO-TROPICAL ORIGINS (SHOWN IN RED) ARE MORE COMMON IN THE WEST. (B) PALEARCTIC BIRDS (SHOWN IN BLUE) ARE MORE COMMON IN THE NORTH. (C) INDO-MALAY BIRDS (SHOWN IN GREEN) ARE MORE COMMON IN THE EAST. (D) COMPOSITE MAP SHOWING THE DOMINANT BIOGEOGRAPHIC AFFINITIES ACROSS THE KINGDOM.

EUROPEAN ROLLER

BECAUSE OF ITS GEOGRAPHICAL POSITION, SAUDI ARABIA HAS BEEN NATURALLY COLONIZED BY BIRDS FROM INDIA, AFRICA, AND EURASIA, SUCH AS THE INDIAN ROLLER (BELOW LEFT), ABYSSINIAN ROLLER (BELOW RIGHT), AND EUROPEAN ROLLER (LEFT), RESPECTIVELY.

INDIAN ROLLER



ABYSSINIAN ROLLER

We also find a healthy collection of birds that are endemic to Arabia – that is, they occur in the Arabian Peninsula and nowhere else on earth (*see* Chapter 6). While some endemic species can be found across much of Saudi Arabia, they are most abundant in the southwest highlands where species have become genetically isolated in the rugged and remote mountain ranges.

In addition, Saudi Arabia's breeding residents share this wide, sandy country with literally millions of migrating birds that pass through Saudi Arabia each year as they travel between their breeding grounds in the northern hemisphere and their wintering grounds in the south. Thus, birds from Iceland, Britain and Norway in the west to Siberia, Alaska and Canada in the east pass through Saudi Arabia on their way to India or Africa. Further, because Saudi Arabia is located in the tropics, it hosts species from the north (Eurasia) that choose to winter in the Kingdom, as well as species from the south (Africa and India) that choose to nest here.

PIED AVOCET, ONE OF AT LEAST 219 SPECIES THAT BREED IN THE KINGDOM.

BREEDING BIRDS

At least 219 species breed in the Kingdom, which represents more than 53% of all Saudi Arabia's regularly occurring birds (*see* Chapter 4). Of these breeding birds, 173 are year-round residents, while 46 species migrate to the Kingdom to breed having spent the non-breeding season outside of Arabia. A greater diversity of breeding residents occurs in the western highlands and Tihama, and at rich feeding sites around Riyadh (*see* Figure 4).

Of the 46 breeding migrants, most arrive from Africa (as far south as Madagascar and Mozambique) and/or India. Four tern species breed in Saudi Arabia after having spent many months foraging in the Arabian Sea and Indian Ocean, with some wintering as far as Japan. Many of the breeding migrants are seabirds, therefore most breeding migrants are found along the coasts, especially in the southern Red Sea. Substantial numbers of breeding migrants also occur around Riyadh. Not surprisingly, no bird species migrate to the Rub' al-Khali to breed (*see* Figure 5).

A further 17 species are regarded as *possibly* breeding in the Kingdom. These are birds in which early season breeding behavior – such as courtship displays, pairing and singing – have been

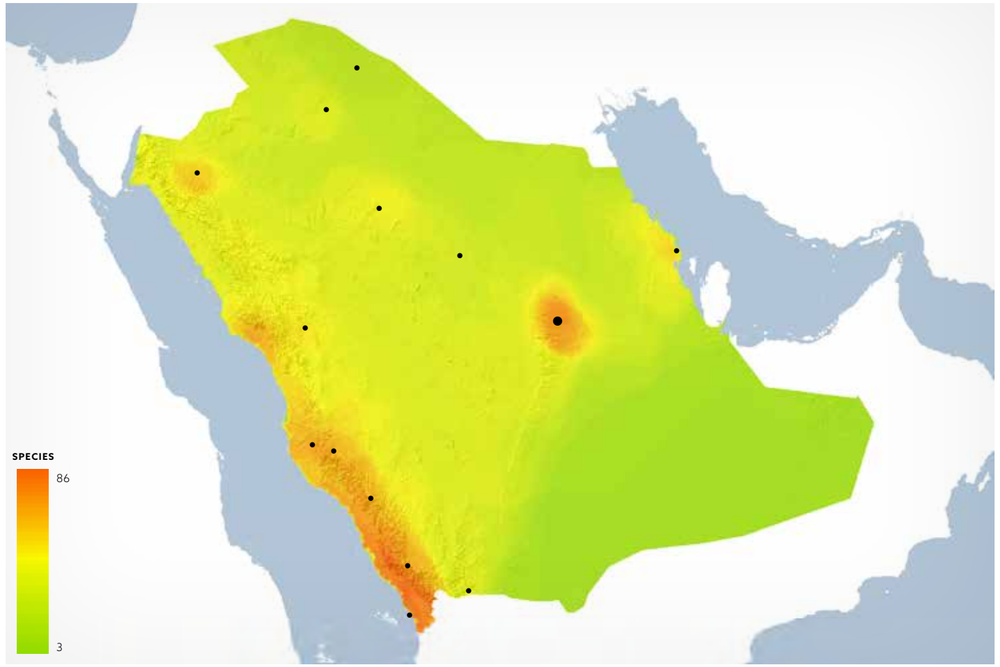


FIGURE 4: HEAT MAP OF BREEDING RESIDENT SPECIES DIVERSITY. REDDER COLORS INDICATE LOCATIONS WITH A GREATER DIVERSITY OF BREEDING RESIDENTS. GREENER COLORS INDICATE LOCATIONS WITH FEWER BREEDING RESIDENTS. THE MINIMUM NUMBER OF RESIDENT SPECIES POTENTIALLY BREEDING AT ANY LOCATION IS 3, WHILE THE MAXIMUM IS 86 IN THE 'ASIR MOUNTAINS.

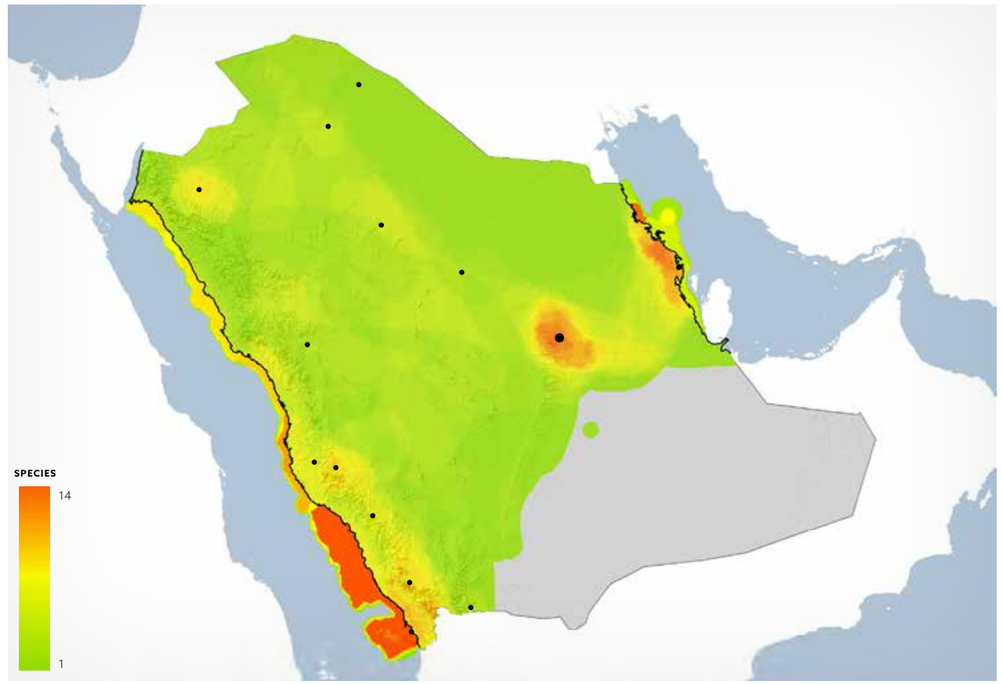


FIGURE 5: HEAT MAP OF BREEDING MIGRANT SPECIES DIVERSITY. REDDER COLORS INDICATE LOCATIONS WITH A GREATER DIVERSITY OF BREEDING MIGRANTS. GREENER COLORS INDICATE LOCATIONS WITH FEWER BREEDING MIGRANTS. GREY AREAS INDICATE ZERO BREEDING MIGRANTS. THE MAXIMUM NUMBER OF SPECIES MIGRATING TO BREED AT ANY LOCATION IS 14 IN THE RED SEA.

THE ARABIAN WAXBILL IS ENDEMIC TO THE MOUNTAINS OF SOUTHWEST SAUDI ARABIA AND YEMEN.

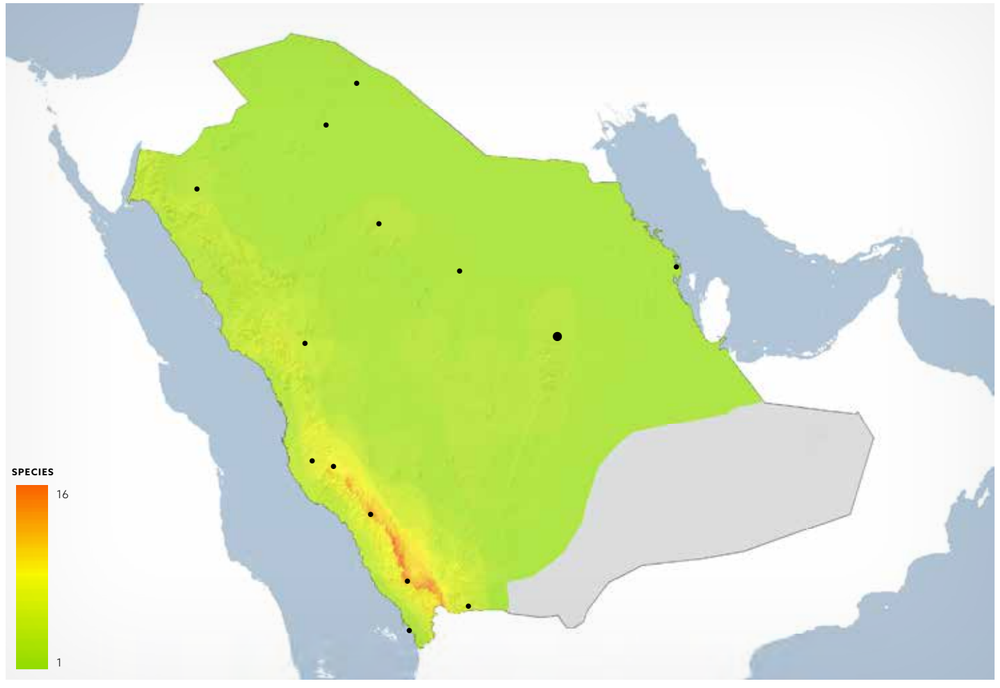
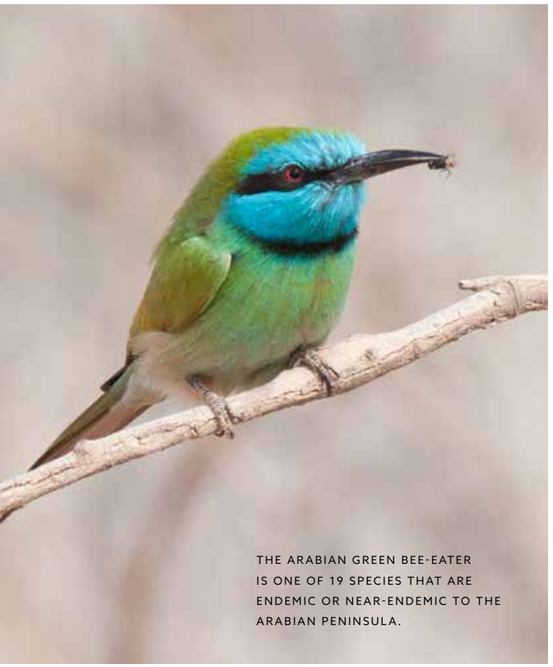


FIGURE 6: HEAT MAP OF REGIONALLY ENDEMIC AND NEAR ENDEMIC SPECIES DIVERSITY. REDDER COLORS INDICATE LOCATIONS WITH A GREATER DIVERSITY OF ENDEMIC OR NEAR ENDEMIC SPECIES. GREENER COLORS INDICATE LOCATIONS WITH FEWER ENDEMICS. GREY AREAS INDICATE ZERO ENDEMIC SPECIES. THE MAXIMUM NUMBER OF ENDEMIC SPECIES BREEDING AT ANY LOCATION IS 16 IN THE 'ASIR MOUNTAINS.



THE ARABIAN GREEN BEE-EATER IS ONE OF 19 SPECIES THAT ARE ENDEMIC OR NEAR-ENDEMIC TO THE ARABIAN PENINSULA.

A MALE RED AVADAVAT COLLECTING NEST MATERIAL. THIS IS ONE OF ONLY 12 INTRODUCED SPECIES THAT BREED REGULARLY IN SAUDI ARABIA.

recorded in spring indicating that these birds may occasionally breed in Saudi Arabia without it yet being observed or reported.

This impressive list of breeding bird species includes 15 species that are endemic to Arabia and four more that are almost endemic (with more than 98% of the global population breeding within the Arabian Peninsula). While at least one endemic or near endemic species can be found anywhere in Saudi Arabia – with the exception of the Rub' al-Khali desert – the majority (16/19) of the Kingdom's regionally endemic or near endemic species occurs in the 'Asir Mountains (*see* Figure 6). Indeed one of these birds, the Asir Magpie, occurs only in the 'Asir Mountains of Saudi Arabia and nowhere else on earth. The list of 175 breeding residents also includes 36 species that have at least one subspecies that is endemic (n=29) or near-endemic (n=7) to Arabia. These 19 endemic and near-endemic species and 36 endemic and near-endemic subspecies are especially important as they help to make the Kingdom's avifauna unique (*see* Chapter 6).

Very few of Saudi Arabia's breeding residents are exotic species that have been deliberately or accidentally introduced into Saudi Arabia (*see* Table 2). Exotic species can be a significant conservation issue if they negatively impact native flora and fauna. For instance, some exotic species may outcompete native birds for food or nest sites, or may introduce novel diseases that local birds cannot tolerate. Fortunately, most of Saudi Arabia's exotic species have 500 or fewer breeding pairs and indeed five contain less than 40 annual breeding pairs in the Kingdom, which may not be sufficient to maintain a sustainable breeding population in the long term. The status of two species in this list needs clarification: the Mallard occurs naturally in the kingdom as a non-breeding species but has been augmented with feral breeding populations, while the White-eared Bulbul may have been native to eastern Saudi Arabia in small numbers though certainly at least some populations have been introduced. Almost all of Saudi Arabia's exotic species are confined to heavily modified habitat in urban areas (*see* Figure 7).

Given the extremes of climate that characterize much of Saudi Arabia, each and every bird that manages to breed successfully within the Kingdom deserves our full respect and admiration.

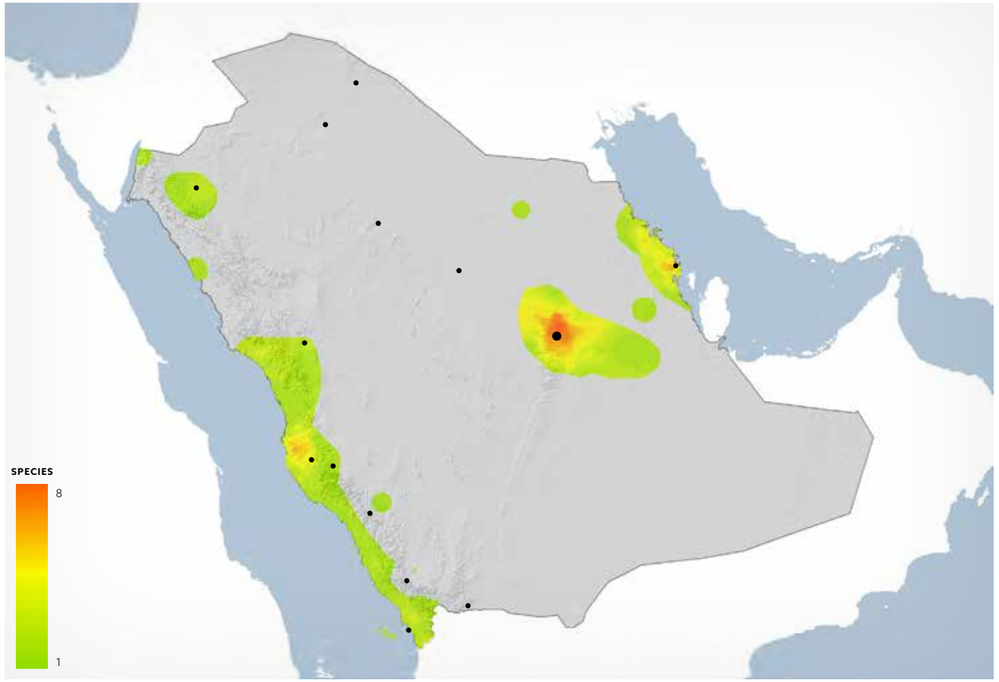


FIGURE 7: HEAT MAP OF INTRODUCED EXOTIC SPECIES DIVERSITY. REDDER COLORS INDICATE LOCATIONS WITH A GREATER DIVERSITY OF INTRODUCED SPECIES. GREENER COLORS INDICATE LOCATIONS WITH FEWER INTRODUCED SPECIES. GREY AREAS INDICATE ZERO INTRODUCED SPECIES. THE MAXIMUM NUMBER OF INTRODUCED SPECIES OCCURRING AT ANY LOCATION IS 8 IN RIYADH. INTRODUCED SPECIES TEND TO OCCUR IN MODIFIED URBAN HABITATS.

THE ENDEMIC ARABIAN WOODPECKER. RESTRICTED TO SAUDI ARABIA AND YEMEN, THIS IS ONE OF THE RAREST WOODPECKERS IN THE WORLD.

TABLE 2: THE DISTRIBUTION AND ABUNDANCE OF EXOTIC SPECIES BREEDING WITHIN SAUDI ARABIA

COMMON NAME	NATIVE RANGE	DISTRIBUTION IN SAUDI ARABIA	ESTIMATED BREEDING PAIRS
White-eared Bulbul	South Asia/Arabia?	Eastern lowlands, Riyadh, Jiddah, Makkah, Tabuk	140,000
Common Myna	South Asia	Eastern lowlands, Riyadh, Jiddah, Makkah, Tabuk	35,000
House Crow	Indian subcontinent	Eastern lowlands, Jazan, Jiddah, Yanbu'	10,000
Rose-ringed Parakeet	South Asia, North Africa	Eastern lowlands, Riyadh, Tihamah	5,000
Red-vented Bulbul	South Asia	Eastern lowlands, Riyadh	500
Red Avadavat	South Asia	Eastern lowlands, Riyadh	300
Mallard	Northern Hemisphere	Large artificial wetlands	200
Alexandrine Parakeet	South Asia	Eastern lowlands, Jiddah	40
Streaked Weaver	South Asia	Eastern lowlands, Riyadh	15
Bank Myna	South Asia	Eastern lowlands, Riyadh	15
Baya Weaver	South Asia	Eastern lowlands, Riyadh	10
Grey Francolin	Indian subcontinent	Eastern lowlands	5
Scaly-breasted Munia	Indian subcontinent	Jiddah, Riyadh, Tayif	5

Saudi Arabia's breeding birds are a testament to the extraordinary capacity of birds to endure heat and drought and sacrifice their own body condition in order to raise their offspring.

NON-BREEDING BIRDS

In total, 281 non-breeding migratory species have been recorded in Saudi Arabia (*see* Chapter 5). One of the reasons why Saudi Arabia receives so many migratory species is that three major flyways pass over the Arabian Peninsula, namely: (i) the East Asia/East Africa Flyway; (ii) the Black Sea/Mediterranean Flyway; and (iii) the Central Asia/South Asia Flyway (*see* Figure 4, Chapter 5). These three flyways bring an array of birds to Saudi Arabia from seemingly disparate regions of the world.

Fifty-two species are recorded in the Kingdom purely as winter visitors. These are birds that breed outside of Saudi Arabia (primarily in Eurasia) before migrating south or southwest to spend the winter months within the Kingdom where the climate is relatively mild. While winter visitors can be found at any place in the Kingdom, they are more likely to be found along the coasts, in the northern half of the Kingdom, or at rich feeding sites around Riyadh (*see* Figure 8).

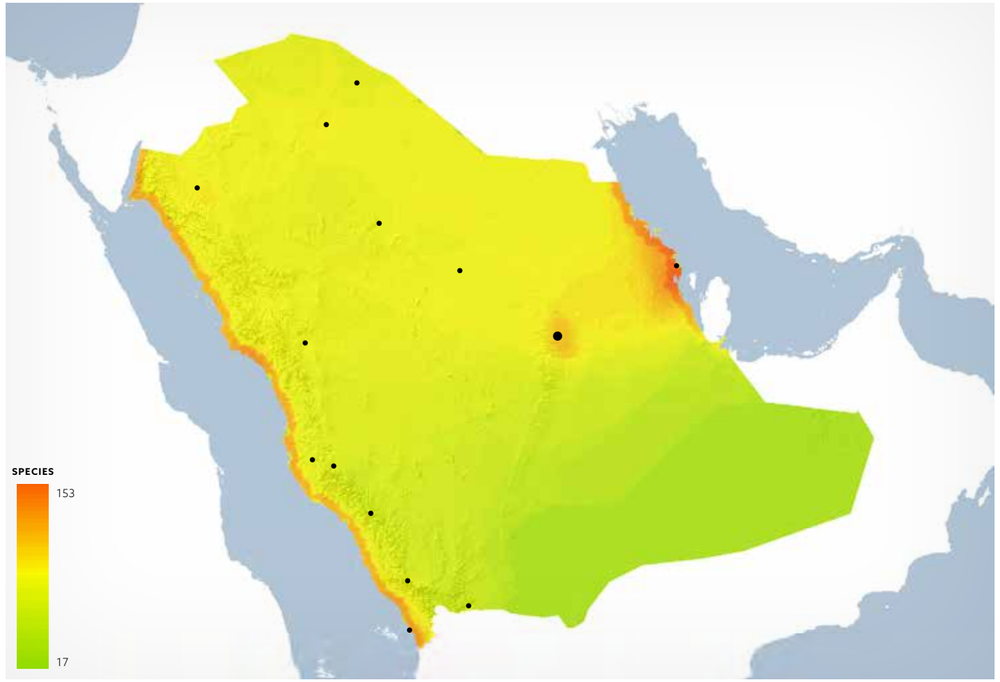


FIGURE 8: HEAT MAP OF WINTER VISITOR SPECIES DIVERSITY. REDDER COLORS INDICATE LOCATIONS WITH A GREATER DIVERSITY OF WINTER VISITORS. GREENER COLORS INDICATE LOCATIONS WITH FEWER WINTER VISITORS. THE MINIMUM NUMBER OF WINTER VISITOR SPECIES OCCURRING AT ANY LOCATION IS 17 IN THE RUB' AL-KHALI, WHILE THE MAXIMUM NUMBER OF PASSAGE MIGRANTS IS 153 ALONG THE COASTS.

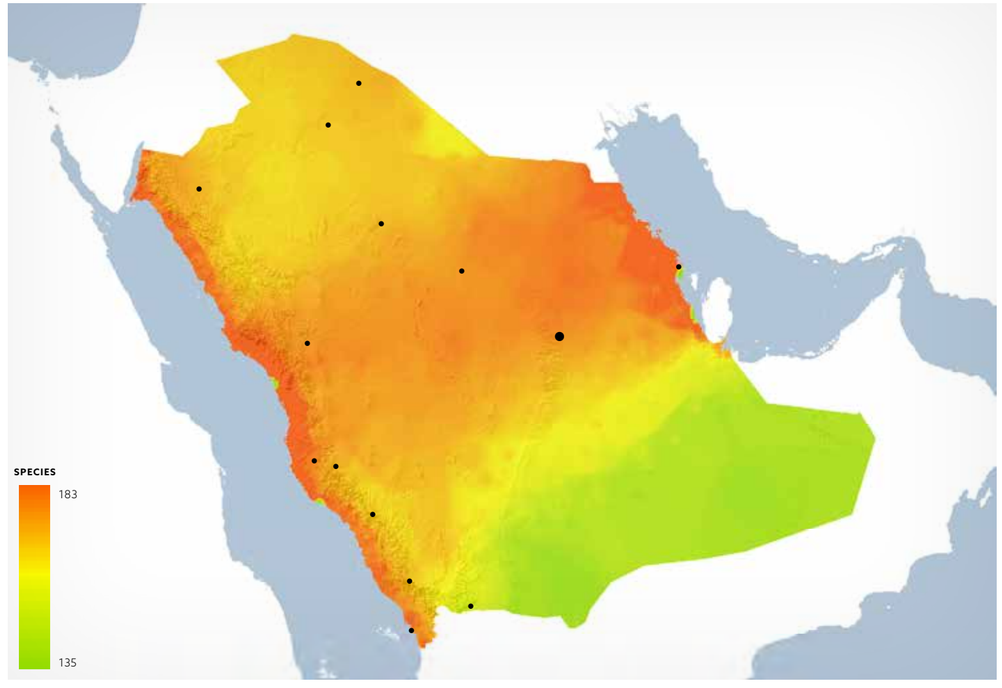


FIGURE 9: HEAT MAP OF PASSAGE MIGRANT SPECIES DIVERSITY. REDDER COLORS INDICATE LOCATIONS WITH A GREATER DIVERSITY OF PASSAGE MIGRANTS. GREENER COLORS INDICATE LOCATIONS WITH FEWER PASSAGE MIGRANTS. THE MINIMUM NUMBER OF PASSAGE MIGRANT SPECIES OCCURRING AT ANY LOCATION IS 135 IN THE RUB' AL-KHALI, WHILE THE MAXIMUM NUMBER OF PASSAGE MIGRANTS IS 183 ALONG THE COASTS.

IN SAUDI ARABIA, 281 NON-BREEDING SPECIES HAVE BEEN RECORDED ANNUALLY, INCLUDING THE MAGNIFICENT CINEREOUS VULTURE.

A further 49 species are recorded solely as passage migrants. These extraordinary birds pass through the Kingdom while migrating thousands of kilometers between their northern breeding grounds and their African or Indian non-breeding grounds. Although passage migrants can be found everywhere in the Kingdom, they are more likely to be found along the coasts, or in a broad band through the center of the Kingdom migrating along the prolific East Asia / East Africa Flyway (*see* Figure 9).

Another 88 species are recorded as *both* winter visitors and passage migrants. Most of these

Given the extremes of climate that characterize much of Saudi Arabia, each and every bird that manages to breed successfully within the Kingdom deserves our full respect and admiration.

The non-breeding birds of Saudi Arabia are truly amazing. These extraordinary travelers should be given safe passage so they can continue their epic voyages unimpeded.

species breed in Eurasia; after breeding, part of the population chooses to stop in Saudi Arabia for the winter while the rest continues further south to winter in Oman, Yemen, Africa, or India. Four more species are recorded as year-round non-breeding visitors; these are either seabirds that regularly forage in Saudi Arabian waters or land birds that visit from nearby breeding sites that could conceivably breed within the Kingdom as well.

In addition, 87 species have been recorded as vagrants only (*see* Volume 2). Vagrants are birds found well outside of their normal range. Most are migratory birds that have become disorientated or blown off course by unusual weather events or have overshot their intended destination. With further surveys in remote areas, we may find that several of these vagrant species in fact occur regularly in the Kingdom.

The non-breeding birds of Saudi Arabia are truly amazing. Many undertake annual round-trip migrations that exceed 10,000 kilometers; others exceed 20,000 kilometers; some even exceed 30,000 kilometers every year just to find suitable breeding and foraging habitat. These extraordinary travelers should be treated as visiting dignitaries to the Kingdom and given safe passage so they can continue their epic voyages unimpeded.

THE WHITE WAGTAIL IS THE MOST COMMON WINTER VISITOR TO SAUDI ARABIA.

A STEPPE EAGLE DRINKS AT SABKHAT AL-FASL, NEAR JUBAIL. A LARGE PORTION OF THE GLOBAL POPULATION OF THIS ENDANGERED SPECIES PASSES THROUGH SAUDI ARABIA EACH YEAR.

THE ASIR MAGPIE OCCURS ONLY IN THE 'ASIR MOUNTAINS OF SAUDI ARABIA AND NOWHERE ELSE. IT IS NOW ONE OF THE 100 MOST-ENDANGERED BIRDS ON EARTH.

THE CONSERVATION STATUS OF SAUDI ARABIA'S BIRDS

While the diversity of birds in Saudi Arabia is surprisingly high, the density of birds is, not surprisingly, low. This is because most of Saudi Arabia is arid or hyper-arid with very low levels of primary productivity. In other words, there are generally few plants, and thus few invertebrates and small vertebrates in the landscape available for birds to eat. Consequently, many of the breeding birds in Saudi Arabia have low total population sizes. Indeed, as demonstrated in Figure 10, 46% of all breeding birds in Saudi Arabia have populations containing less than 1,000 annual breeding pairs, while 23% have populations with less than 100 annual breeding pairs.

This is concerning because small populations are particularly vulnerable to extinction in the face of any additional population decline. Moreover, they are susceptible to pernicious genetic problems such as inbreeding and a loss of genetic diversity, as well as disease, climatic events, and demographic stochasticity. If a population contains, say, only 40 breeding pairs, then essentially *any* nest failure has a significant impact on population size. Small populations can easily enter an "extinction vortex" whereby populations become increasingly small simply because they are already small. [2]Unfortunately, as is the case in many countries, the birds of Saudi Arabia are suffering widespread ongoing declines as a result of desertification, habitat loss, hunting, secondary poisoning, collision with electricity cables, climatic shifts, ingestion of plastic, and many other threatening processes.[3]

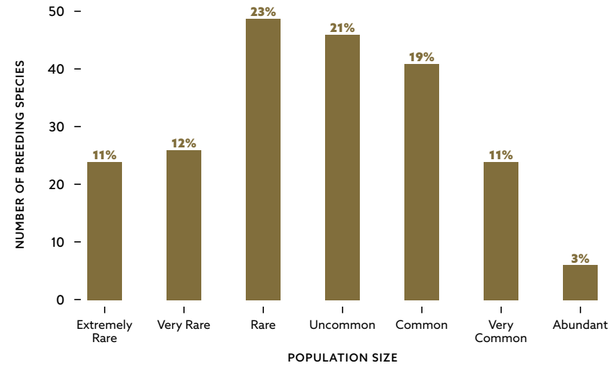


FIGURE 10: POPULATION SIZE CLASSES OF ALL BREEDING SPECIES IN SAUDI ARABIA.

The numbers above the bars indicate the percentage of species in each category. Population size equals the estimated number of annual breeding pairs as per the following categories: Extremely Rare = 1–10 pairs; Very Rare = 11–100 pairs; Rare = 101–1,000 pairs; Uncommon = 1,001–10,000 pairs; Common = 10,001–100,000 pairs; Very Common = 100,000–1,000,000 pairs; Abundant > 1,000,000 pairs.[4]

THE MAGNIFICENT TAWNY EAGLE IS LISTED AS GLOBALLY VULNERABLE AND REGIONALLY ENDANGERED. ONLY 100 BREEDING PAIRS REMAIN IN SAUDI ARABIA.

REGIONAL CONSERVATION STATUS

The collective threats facing the birds of Saudi Arabia are having an impact on the conservation status of many species across the Kingdom. In 2015, the IUCN provided regional conservation assessments for 329 bird species occurring in the Arabian Peninsula,[5] including 258 species that occur in Saudi Arabia. In total, 21% of Saudi Arabia's regionally assessed birds are decreasing within the Arabian Peninsula (*see* Figure 11). It is quite concerning that more than one in five bird species in Saudi Arabia is currently experiencing a significant population decline. What's more, two species are listed as undergoing a "very rapid decline" within Arabia; these are the famous Asian Houbara and the Arabian Bustard. Sadly, the decline for both these species is now almost complete – only an estimated 30 breeding pairs remain for the Asian Houbara, while just one individual Arabian Bustard has been seen in almost 30 years.

Interestingly 25% of assessed species are increasing at the regional level (*see* Figure 11), which means more species are increasing than decreasing within the Kingdom. However, most of the species that are increasing in Saudi Arabia occur in human modified habitats, specifically wetlands, farmlands, and settled areas, such as cities and towns. Conversely, most of the species that are decreasing occur in areas of relatively intact natural habitat, such as arid areas, scrublands, acacia woodlands, coastal areas, and, in particular, the southwest highlands where so many of the Kingdom's endemic species and subspecies occur (*see* Figure 17). Consequently, birds in natural habitats tend to have a poorer conservation status than birds in modified habitats.[7] Given that almost half of Saudi Arabia's birds are either increasing (25%) or decreasing (21%), it is quite clear that a rapid and momentous shift is currently occurring in the birds of Saudi Arabia (*see* Figure 16).

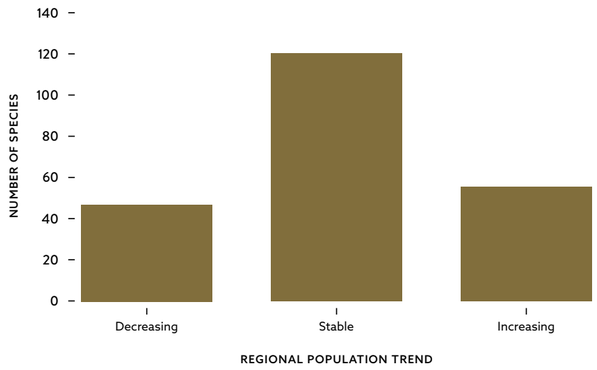
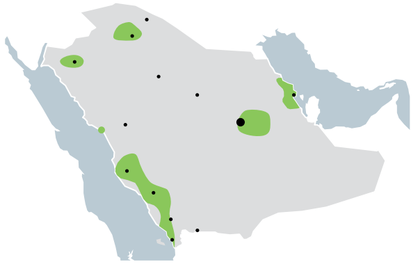


FIGURE 11: REGIONAL POPULATION TRENDS OF 224 BIRD SPECIES REGULARLY RECORDED IN SAUDI ARABIA.[6]

THE FAMOUS ASIAN HOUBARA IS EXPERIENCING A VERY RAPID DECLINE ACROSS ARABIA. PERHAPS ONLY 30 PAIRS NOW BREED IN THE KINGDOM. THIS BIRD IS PART OF A CAPTIVE BREEDING PROGRAM IN TAYIF.

AN ASIAN HOUBARA WITH A SATELLITE TRANSMITTER ON ITS BACK AT EMAM SAUD BIN MOHAMMED PROTECTED AREA NEAR TAYIF. TRACKING AND CAPTIVE BREEDING ARE BEING USED TO TRY AND RESTORE THE ENDANGERED LOCAL POPULATION.

PURPLE SWAMPHEN.
BIRDS THAT LIVE IN
WETLAND HABITATS TEND
TO BE INCREASING.



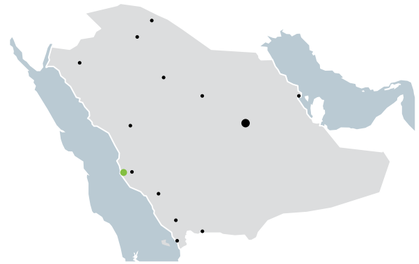
HOUSE SPARROW 1980 DISTRIBUTION

HOUSE SPARROW CURRENT DISTRIBUTION

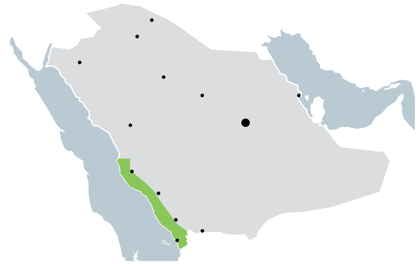
FIGURE 12: THE HISTORIC AND CURRENT RANGE OF HOUSE SPARROW IN SAUDI ARABIA. SPECIES THAT CAN EXPLOIT URBAN LANDSCAPES, ARTIFICIAL WETLANDS, OR FARMLANDS HAVE BENEFITTED IN RECENT DECADES.

BLACK SCRUB-ROBIN.
BIRDS THAT CAN LIVE
IN FARMLAND HABITATS
TEND TO BE INCREASING.

CRAB PLOVER. BIRDS THAT LIVE IN COASTAL HABITATS TEND TO BE DECREASING.



NAMAQUA DOVE 1934 DISTRIBUTION



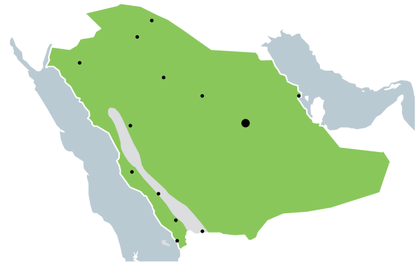
NAMAQUA DOVE 1980 DISTRIBUTION

NAMAQUA DOVE CURRENT DISTRIBUTION

FIGURE 13: THE RAPIDLY EXPANDING RANGE OF NAMAQUA DOVE IN SAUDI ARABIA. SPECIES THAT CAN EXPLOIT AGRICULTURAL LANDSCAPES ARE EXPERIENCING SIGNIFICANT INCREASES IN DISTRIBUTION AND ABUNDANCE IN SAUDI ARABIA.

COMMON MYNA. BIRDS THAT CAN LIVE IN URBAN HABITATS TEND TO BE INCREASING.

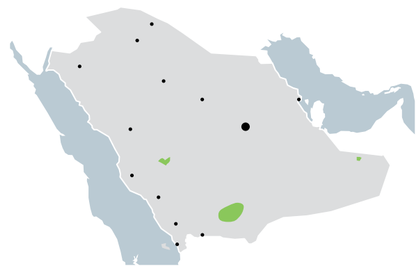
AN ARABIAN MOURNING WHEATEAR. BIRDS THAT LIVE IN ARID AND ROCKY HABITATS TEND TO BE DECREASING.



COMMON OSTRICH HISTORIC DISTRIBUTION

COMMON OSTRICH 1850 DISTRIBUTION

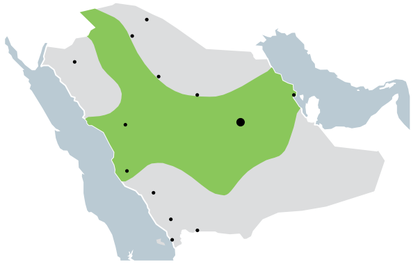
COMMON OSTRICH 1980 DISTRIBUTION



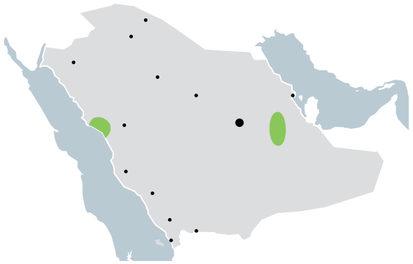
COMMON OSTRICH CURRENT DISTRIBUTION

FIGURE 14: THE REGIONAL EXTINCTION AND REINTRODUCTION OF COMMON OSTRICH IN SAUDI ARABIA.

BROWN WOODLAND-WARBLER. BIRDS THAT LIVE IN ALPINE HABITATS TEND TO BE DECREASING.



SPOTTED SANDGROUSE 1980 DISTRIBUTION[1]



SPOTTED SANDGROUSE CURRENT DISTRIBUTION[1]

FIGURE 15: THE RAPIDLY DIMINISHING RANGE OF SPOTTED SANDGROUSE IN SAUDI ARABIA. 21% OF THE KINGDOM'S BIRDS ARE EXPERIENCING SIGNIFICANT POPULATION DECLINES. MEDIUM TO LARGE BIRDS SUCH AS THESE HAVE SUFFERED GREATLY IN RECENT DECADES.

THE RANGE OF SPOTTED SANDGROUSE HAS DECREASED DRAMATICALLY WITHIN SAUDI ARABIA IN RECENT DECADES.

THE LARGEST BIRD IN THE WORLD, THE OSTRICH, ONCE ROAMED THE ARABIAN PENINSULA BUT WAS HUNTED TO EXTINCTION IN THE 1900S. BIRDS FROM NORTHERN AFRICA HAVE BEEN REINTRODUCED INTO PROTECTED AREAS, INCLUDING AT SHAYBAH WILDLIFE SANCTUARY (PICTURED).

This shift in the Kingdom's avifauna is favoring smaller birds at the expense of larger birds.[9] Species that are decreasing tend to be heavier and larger than those species that are stable or increasing (*see* Figure 18). There are several reasons why larger birds are more likely to be declining compared to smaller birds. Large birds are presumably more attractive to hunters and may be more likely to be persecuted by landowners. Further, larger birds are often long-lived predators or scavengers, and as such they are more vulnerable to secondary poisoning and biomagnification. They typically require a greater amount of prey than smaller birds and thus have larger home ranges, making them especially vulnerable to habitat loss and fragmentation. In addition, larger birds may be more vulnerable to collision with power lines and other cables. Finally, larger birds – especially those in arid environments – usually take longer to achieve reproductive maturity and reproduce less often; they lay smaller clutches (often only a single egg) and take a long time to fledge their chicks.[10] These traits make larger birds very vulnerable at a population level to any additional mortality with limited capacity for population recovery.

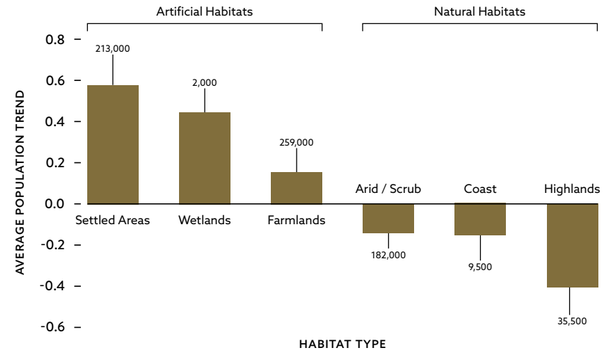


FIGURE 17: MEAN REGIONAL POPULATION TRENDS AND NATIONAL POPULATION SIZES FOR 188 BREEDING SPECIES IN VARIOUS NATURAL AND ARTIFICIAL HABITAT TYPES.

A score of +1 would indicate that all species within that habitat type are increasing, whereas a score of -1 would indicate that all species are decreasing.[8] *Figures adjacent to columns are the mean number of annual breeding pairs for species within each habitat type. Bars represent standard error.*

As a result of these cumulative threats, larger and heavier birds are more likely to have significantly poorer regional conservation status compared to smaller and lighter birds. For example,

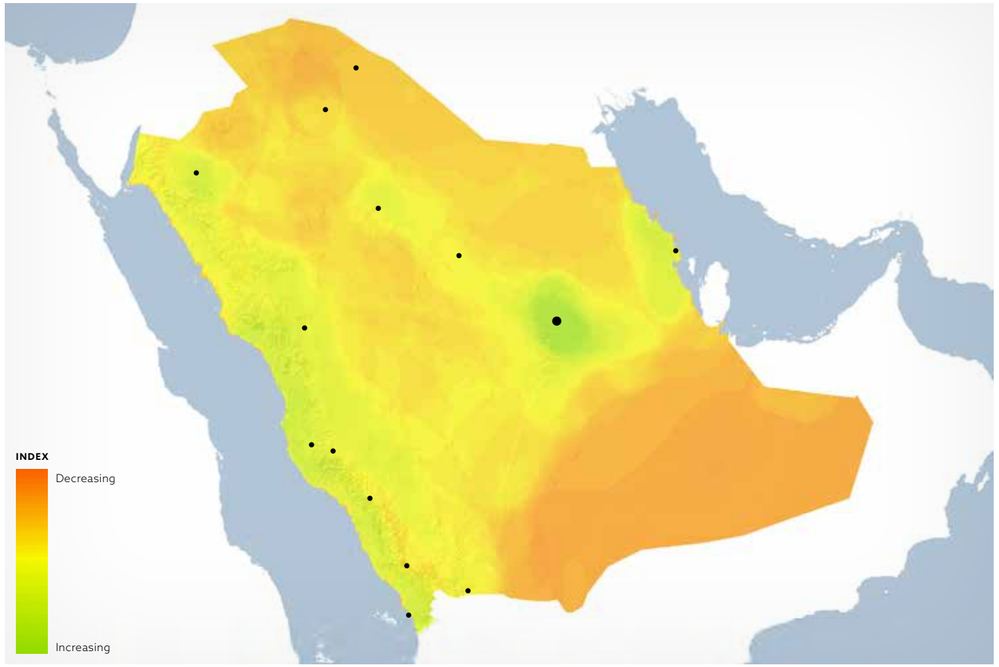


FIGURE 16: HEAT MAP OF SPECIES' REGIONAL CONSERVATION TRENDS[11]. REDDER COLORS INDICATE LOCATIONS WHERE A GREATER PROPORTION OF POPULATIONS ARE DECREASING IN ABUNDANCE, SUCH AS DESERT AND HIGHLAND HABITATS. GREENER COLORS INDICATE LOCATIONS WHERE POPULATIONS TEND TO BE INCREASING IN ABUNDANCE, SUCH AS URBAN AND AGRICULTURAL HABITATS.

THE RANGE OF NAMAQUA DOVE HAS INCREASED DRAMATICALLY WITHIN SAUDI ARABIA IN RECENT DECADES DUE TO THE SPREAD OF AGRICULTURE.

THE TINY PALESTINE SUNBIRD. SMALL BIRDS TEND TO BE STABLE OR INCREASING IN SAUDI ARABIA.

of the 258 Saudi Arabian species that have had their regional conservation status assessed by the IUCN, the nine heaviest species are all regionally threatened (*see* Table 3). Indeed, the heaviest bird of all – the Ostrich – went extinct throughout Arabia several decades ago but has since been reintroduced into fenced protected areas (*see* Figure 14). To put it another way, while 9% of the lightest 100 species are threatened or near-threatened, over 30% of the heaviest 100 species are threatened or near-threatened. In short, Saudi Arabia's larger birds are steadily disappearing from the landscape, and that is a tragedy.

The decrease in large iconic birds in Saudi Arabia is evident when examining the list of 50 High Conservation Priority species developed by the former National Commission for Wildlife Conservation and Development (now the Saudi Wildlife Authority) in 2003. These 50 species are birds with particularly high national value, such as flagship species, birds that are economically or culturally important, birds that are endemic or have internationally significant populations occurring within the Kingdom, birds that are globally threatened, and birds in which Saudi Arabia is essential to the conservation of the species.[12] The IUCN has assessed the regional conservation status of 44 of these 50 species.[13] While this list is now understandably somewhat out of date as a result of recent taxonomic revisions, it is nonetheless concerning that 24/44 (55%) assessed High

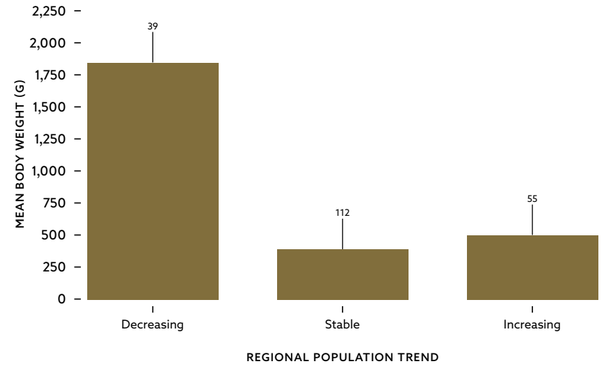


FIGURE 18: MEAN BODY MASS OF REGIONALLY DECREASING, STABLE OR INCREASING BIRDS IN SAUDI ARABIA. BARS INDICATE STANDARD ERROR. NUMBERS ABOVE BARS INDICATE NUMBER OF SPECIES IN EACH CATEGORY.

Conservation Priority species are formally listed as decreasing regionally by the IUCN. Only three species are listed as increasing (n=1) or possibly increasing (n=2), while the remaining 17 species are stable.

Overall, 29 species regularly occurring within Saudi Arabia are listed as regionally threatened by the IUCN (*see* Table 4; Figure 20a), with several at risk of becoming extinct within the Kingdom. Indeed, four may already be locally extinct, namely the Arabian Bustard, Bateleur, Bearded Vulture and Northern Bald Ibis, while the Arabian subspecies of the Common Ostrich went extinct several

More than one in five bird species in Saudi Arabia is currently experiencing a significant population decline.

THE ENORMOUS PINK-BACKED PELICAN. LARGE BIRDS TEND TO BE DECREASING IN SAUDI ARABIA.

THE LESSER CRESTED TERN, ONE OF 50 BIRD SPECIES LISTED NATIONALLY AS BEING OF HIGH CONSERVATION PRIORITY BY THE SAUDI WILDLIFE AUTHORITY. SAUDI ARABIA IS ESSENTIAL TO THE CONSERVATION OF THIS SPECIES.

THE OSPREY IS NATIONALLY LISTED AS A SPECIES OF HIGH CONSERVATION PRIORITY BECAUSE IT PLAYS A SIGNIFICANT ROLE IN MAINTAINING A BALANCED ECOSYSTEM.

TABLE 3: REGIONAL CONSERVATION STATUS OF SAUDI ARABIA'S 12 HEAVIEST BIRD SPECIES.

COMMON NAME	MEAN BODY MASS (G)	SAUDI ARABIAN BREEDING PAIRS	REGIONAL POPULATION TREND	REGIONAL CONSERVATION STATUS
Common Ostrich	128,000	80	Stable	Extinct in the wild
Arabian Bustard	12,350	0?	Very rapid decline	Critically endangered
Golden Eagle	8,840	200	Decreasing	Endangered
Griffon Vulture	8,500	2,500	Decreasing	Endangered
Verreaux's Eagle	8,025	25	Increasing	Endangered
Lappet-faced Vulture	7,400	500	Decreasing	Vulnerable
Bearded Vulture	5,800	0?	Possibly decreasing	Vulnerable
Pink-backed Pelican	5,450	400	Decreasing	Vulnerable
Goliath Heron	4,390	60	Possibly stable	Endangered
Pharaoh Eagle-owl	4,200	2,200	Possibly increasing	Least concern
Asian Houbara	3,950	30	Very rapid decline	Critically endangered
Tawny Eagle	2,350	100	Decreasing	Endangered

decades ago. Furthermore, the Asian Houbara and the Lanner Falcon are both critically endangered and their small estimated populations of 30 and 10 breeding pairs respectively are both experiencing rapid declines. In addition, the regionally endangered Tawny Eagle, Asir Magpie and Golden Eagle all have small and decreasing populations (containing less than 200 pairs), and thus are also at high risk of local extinction. While it is definitely concerning that 29 of Saudi Arabia's bird species are regionally threatened, the proportion of threatened species in the Kingdom is comparable with the conservation status of the world's bird species (*see* Table 5; Figure 20b).

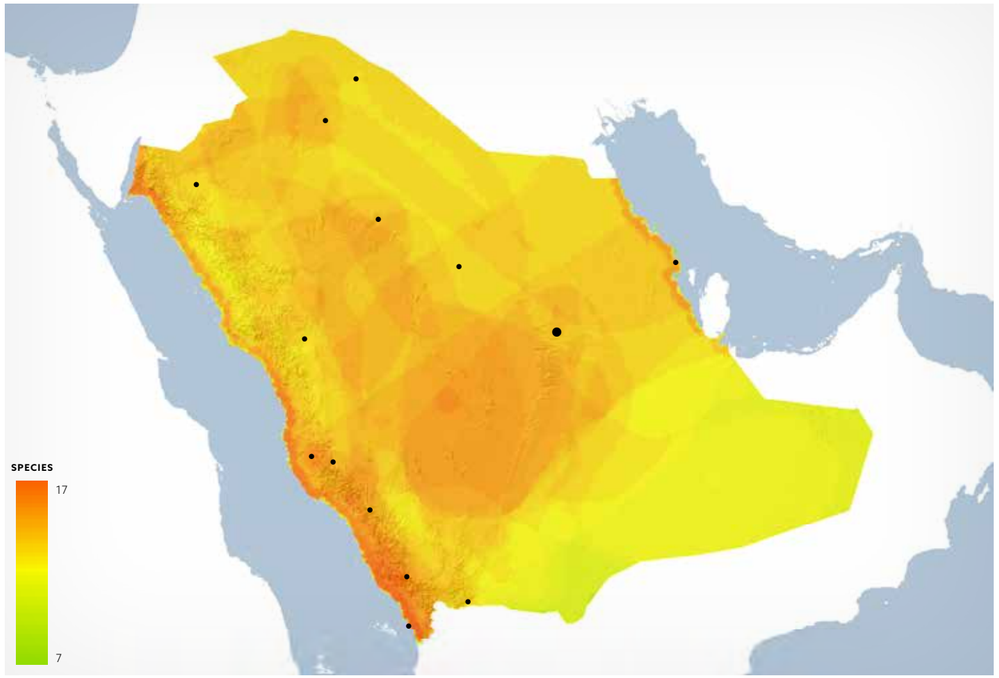


FIGURE 19: HEAT MAP OF SPECIES' REGIONAL CONSERVATION STATUS. REDDER COLORS INDICATE LOCATIONS WHERE POPULATIONS TEND TO BE REGIONALLY THREATENED WITH EXTINCTION (CRITICALLY ENDANGERED, ENDANGERED OR VULNERABLE). GREENER COLORS INDICATE LOCATIONS WHERE POPULATIONS TEND TO BE REGIONALLY SAFE (LEAST CONCERN OR NEAR THREATENED). THE AREA WITH THE MOST NUMBER OF REGIONALLY THREATENED SPECIES IS THE SOUTHERN RED SEA COAST WITH 17. THE AREA WITH THE FEWEST REGIONALLY THREATENED SPECIES IS THE RUB' AL-KHALI WITH SEVEN.

THE GOLDEN EAGLE IS ONE OF 29 REGIONALLY THREATENED BIRD SPECIES THAT OCCUR IN SAUDI ARABIA.

TABLE 4: REGIONALLY THREATENED BIRD SPECIES OCCURRING IN SAUDI ARABIA.

REGIONAL CONSERVATION STATUS	REGIONAL POPULATION TREND	NATIONAL RESIDENCE STATUS	NATIONAL BREEDING PAIRS
REGIONALLY EXTINCT (N=1)			
COMMON OSTRICH	STABLE	BREEDING RESIDENT	80[R]
CRITICALLY ENDANGERED (N=5)			
ARABIAN BUSTARD	VERY RAPID DECLINE	BREEDING RESIDENT	0?
ASIAN HOUBARA	VERY RAPID DECLINE	BREEDING RESIDENT	30[R]
NORTHERN BALD IBIS	DECREASING	WINTER VISITOR	0
LANNER FALCON	DECREASING	BREEDING RESIDENT	10
SAKER FALCON	UNKNOWN	WINTER VISITOR	0
ENDANGERED (N=13)			
AFRICAN OLIVE-PIGEON	STABLE	BREEDING RESIDENT	75
BLACK-BELLIED SANDGROUSE	UNKNOWN	WINTER VISITOR	0
GOLIATH HERON	POSSIBLY STABLE	BREEDING RESIDENT	60
GRIFFON VULTURE	DECREASING	BREEDING RESIDENT	2,500
TAWNY EAGLE	DECREASING	BREEDING RESIDENT	100
GOLDEN EAGLE	DECREASING	BREEDING RESIDENT	200
VERREAUX'S EAGLE	INCREASING	BREEDING RESIDENT	25
COLLARED KINGFISHER	DECREASING	BREEDING RESIDENT	300
SOOTY FALCON	DECREASING	BREEDING RESIDENT	300
PEREGRINE FALCON	POSSIBLY INCREASING	BREEDING RESIDENT	600
ASIR MAGPIE	DECREASING	BREEDING RESIDENT	100
BASRA REED-WARBLER	UNKNOWN	BREEDING MIGRANT	10
EUROPEAN GOLDFINCH	DECREASING	BREEDING MIGRANT	2,000
VULNERABLE (N=10)			
HELMETED GUINEAFOWL	DECREASING	BREEDING RESIDENT	500
HAMERKOP	DECREASING	BREEDING RESIDENT	1,500
PINK-BACKED PELICAN	DECREASING	BREEDING RESIDENT	400
SOCOTRA CORMORANT	DECREASING	BREEDING RESIDENT	35,000
CRAB-PLOVER	DECREASING	BREEDING RESIDENT	1,400
BLACK-WINGED KITE	INCREASING	BREEDING RESIDENT	3
BEARDED VULTURE	POSSIBLY DECREASING	BREEDING RESIDENT	0?
EGYPTIAN VULTURE	DECREASING	BREEDING RESIDENT	50
SHORT-TOED SNAKE-EAGLE	STABLE	BREEDING RESIDENT	120
LAPPET-FACED VULTURE	POSSIBLY DECREASING	BREEDING RESIDENT	500

[R] REINTRODUCED INTO FENCED PROTECTED AREAS

THE EXQUISITE COLLARED KINGFISHER IS REGIONALLY ENDANGERED WITHIN THE ARABIAN PENINSULA.

THE ARABIAN BUSTARD IS CRITICALLY ENDANGERED IN ARABIA. ONLY ONE BIRD HAS BEEN SEEN IN THE KINGDOM IN THE LAST 27 YEARS. FORTUNATELY A POPULATION STILL EXISTS IN AFRICA.

TABLE 5: REGIONAL CONSERVATION STATUS OF ASSESSED SAUDI ARABIAN BIRDS VERSUS GLOBAL CONSERVATION STATUS OF ALL BIRDS.

	SAUDI ARABIAN SPECIES		NON-SAUDI ARABIAN SPECIES	
CONSERVATION STATUS	*NUMBER OF SPECIES*	*%*	*NUMBER OF SPECIES*	*%*
LEAST CONCERN	203	78.7	8,405	75.9
NEAR-THREATENED	26	10.1	1,012	9.1
VULNERABLE	10	3.9	799	7.2
ENDANGERED	13	5.0	469	4.2
CRITICALLY ENDANGERED	5	1.9	224	2.0
EXTINCT IN THE WILD	1	0.4	5	0.0
EXTINCT	0	0.0	156	1.4
TOTAL	**258**	**100**	**11,070**	**100**

THE ICONIC SAKER FALCON IS CRITICALLY ENDANGERED WITHIN ARABIA.

THE BATELEUR HAS NOT BEEN RECORDED IN SAUDI ARABIA SINCE 1999.

INTERNATIONAL CONSERVATION STATUS

The Kingdom of Saudi Arabia has an important role to play in the international effort to protect the world's birds. Of the 401 native species regularly occurring in Saudi Arabia, 362 have had their global population trend confidently assessed. Ominously, 147 of these species (41%) are declining globally. Saudi Arabia supports at least 17 species that are globally threatened (*see* Table 6; Figure 20b) as well as 24 near-threatened species. Thus 10% of Saudi Arabia's birds are listed as globally threatened or near-threatened. One of these species is critically endangered, namely Sociable Lapwing. A considerable proportion of the remaining population migrates through the north of Saudi Arabia each year, while some individuals remain in the Kingdom over winter.[14] Further, the endangered Northern Bald Ibis is probably extinct in the region and the critically endangered Slender-billed Curlew (which has never been identified with certainty in the Kingdom) may be extinct globally. Significantly, one of the most endangered species in Saudi Arabia, the Asir Magpie, is endemic to the Kingdom. The entire global population resides within a few small patches of habitat in the 'Asir Mountains. These birds, in particular, are relying upon the people of Saudi Arabia for their continued existence.

Four species may already be extinct within Saudi Arabia, namely the Arabian Bustard, Bateleur, Bearded Vulture and Northern Bald Ibis.

THE BEARDED VULTURE MAY NOW BE EXTINCT IN ARABIA.

Saudi Arabia supports at least 17 species that are globally threatened.

TABLE 6: GLOBALLY THREATENED SPECIES OCCURRING IN SAUDI ARABIA.

GLOBAL CONSERVATION STATUS	GLOBAL POPULATION TREND	NATIONAL RESIDENCE STATUS	NATIONAL BREEDING PAIRS
CRITICALLY ENDANGERED (N=1)			
SOCIABLE LAPWING	DECREASING	WINTER VISITOR	0
ENDANGERED (N=8)			
GREAT KNOT	DECREASING	WINTER VISITOR	0
NORTHERN BALD IBIS	STABLE	WINTER VISITOR	0
EGYPTIAN VULTURE	DECREASING	BREEDING RESIDENT	50
LAPPET-FACED VULTURE	DECREASING	BREEDING RESIDENT	500
STEPPE EAGLE	DECREASING	WINTER VISITOR	0
SAKER FALCON	DECREASING	WINTER VISITOR	0
ASIR MAGPIE	DECREASING	BREEDING RESIDENT	100
BASRA REED-WARBLER	STABLE	BREEDING MIGRANT	10
VULNERABLE (N=8)			
COMMON POCHARD	DECREASING	PASSAGE MIGRANT	0
EUROPEAN TURTLE-DOVE	DECREASING	BREEDING MIGRANT	1,600
ASIAN HOUBARA	DECREASING	BREEDING RESIDENT	30
SOCOTRA CORMORANT	DECREASING	BREEDING RESIDENT	35,000
GREATER SPOTTED EAGLE	DECREASING	WINTER VISITOR	0
TAWNY EAGLE	DECREASING	BREEDING RESIDENT	100
EASTERN IMPERIAL EAGLE	DECREASING	WINTER VISITOR	0
SOOTY FALCON	DECREASING	BREEDING RESIDENT	300

THE GREATER SPOTTED EAGLE IS LISTED AS GLOBALLY VULNERABLE. THIS IMPRESSIVE BIRD IS STILL A JUVENILE.

GLOBALLY ENDANGERED GREAT KNOTS SPEND THE WINTER IN SAUDI ARABIA.

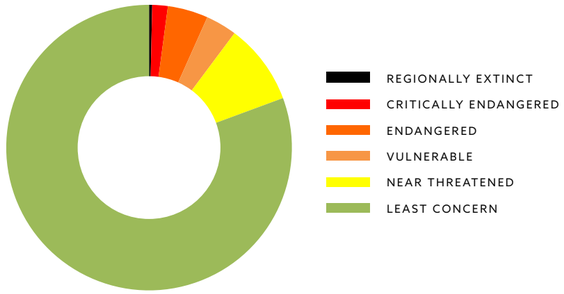


FIGURE 20A: REGIONAL CONSERVATION STATUS OF THE BIRDS OF SAUDI ARABIA.

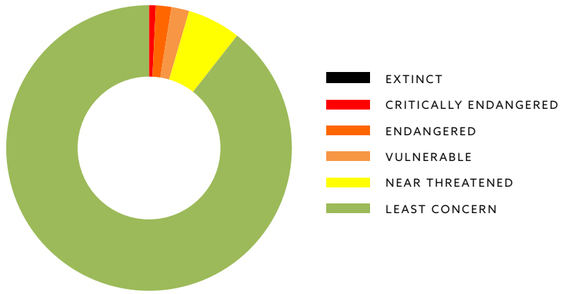
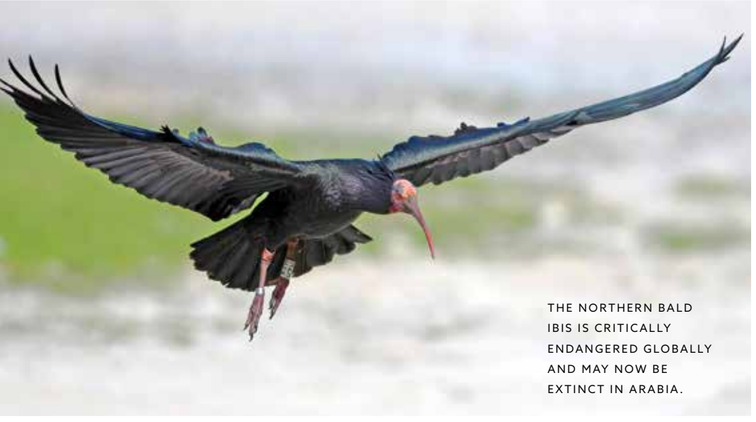


FIGURE 20B: GLOBAL CONSERVATION STATUS OF THE BIRDS OF SAUDI ARABIA.



THE NORTHERN BALD IBIS IS CRITICALLY ENDANGERED GLOBALLY AND MAY NOW BE EXTINCT IN ARABIA.

LISTED AS GLOBALLY VULNERABLE, THE EUROPEAN TURTLE-DOVE IS DECLINING RAPIDLY ACROSS ITS RANGE. CURRENTLY AROUND 1,600 PAIRS BREED ANNUALLY IN SAUDI ARABIA.

THE SOCIABLE LAPWING IS CRITICALLY ENDANGERED GLOBALLY; A LARGE PERCENTAGE OF THE GLOBAL POPULATION MIGRATES THROUGH NORTHERN SAUDI ARABIA EACH YEAR.

CONCLUSION

The distribution and abundance of the birds of Saudi Arabia are currently undergoing a rate of change that is probably unprecedented in history. In the face of rapidly changing ecosystems, a quarter of all of Saudi Arabia's birds are significantly increasing, while more than a fifth are visibly decreasing. Birds that live in more natural ecosystems, such as the southwest highlands, desert landscapes and coastal areas, are suffering whereas those that live in human-created habitats, such as constructed wetlands, farmlands and cities, are increasing. Sadly, many of our large and iconic species are disappearing. Although several species now occur in very small numbers within the Kingdom, there is still time to address these imbalances and protect the Kingdom's most endangered birds.

A GLOBALLY ENDANGERED BASRA REED-WARBLER IS TAGGED AND RELEASED FOR SCIENTIFIC MONITORING. THE DELICATE FATE OF MANY SPECIES RESTS IN OUR HANDS

A LANNER FALCON, ONE OF THE MOST CULTURALLY IMPORTANT BIRDS OF ARABIA

CHAPTER 2

The Importance of Birds in Arabian Culture

KEY POINTS

- Birds have always been an important and uplifting theme in Arabian art.
- The earliest visual artworks in Arabia are 10,000-year-old rock engravings that depict birds.
- The earliest Arabic poetry also depicts birds, with birds mentioned in poems dating back more than 1,400 years.
- The earliest Arabic proverbs, folktales and folksongs also regularly feature birds.
- One of the world's oldest sports – falconry – is based on a deep respect for birds, and has been practiced in Arabia for thousands of years.
- The word of God, the Holy Qur'an, reveals the significance of birds.
- When we care for birds, we care for our cultural heritage.

A BLUETHROAT. THROUGHOUT HISTORY THE PEOPLE OF ARABIA HAVE BEEN BEGUILED BY THE DELICATE BEAUTY OF BIRDS.

THE LONG HISTORY OF BIRDS IN ARABIAN CULTURE

For thousands of years, the people of Arabia have shared this vast arid landscape with hundreds of species of birds. They viewed these remarkable animals not just as sources of food, but also as sources of information, inspiration, hope, and happiness.

The nomadic peoples of Arabia studied and contemplated birds. They developed an intimate understanding of bird behavior, as well as profound respect and admiration for the birds themselves. Then, around 12,000 years ago, the first small settlements and villages began to emerge in the Arabian Peninsula. Soon after, commensal species like pigeons, doves and sparrows began to live in close quarters with people, allowing the early Arabs to develop a closer relationship with birds than ever before.

Throughout this long history, birds have beguiled the people of Arabia with their beauty, their songs, their fragility, their grandeur, and their prowess. In an unforgiving and sparse land, the sight or the sound or even the thought of a bird must have brought great comfort and joy. It is no wonder then that birds have been one of the most common and enduring motifs in ancient Arabian art, poetry, music, sport, folklore, and religion.

EUROPEAN BEE-EATERS ARRIVE IN SPRING AND AUTUMN, ANNOUNCING THE CHANGE OF SEASONS.

THE NILE VALLEY SUNBIRD SURELY SPARKS HAPPINESS IN EVERY PERSON WHO SEES ONE.

BIRDS IN ANCIENT ARABIAN ART

About 70 kilometers northwest of Hayil, near the town of Jubbah, lies an astonishing collection of art dating to the Neolithic period. Rock panels are crowded with literally thousands of engravings of human figures and wild animals, including unmistakable images of lions and aurochs – mammals that are now regionally and globally extinct, respectively – along with oryx, ibex, gazelle, onager, and birds, specifically ostrich. For example, one petroglyph clearly depicts two adult ostrich standing beside four juveniles. Another site, Shuwaymis, contains perhaps even more rock art than Jubbah, and it too includes numerous etchings of ostrich and their young. In fact, the ancient artwork at Jubbah and Shuwaymis is so abundant – and so

AS PEOPLE BEGAN LIVING IN SETTLED VILLAGES, THEY BECAME CLOSELY ACQUAINTED WITH COMMENSAL BIRDS LIKE THE HOUSE SPARROW.

A WESTERN YELLOW WAGTAIL WADES THROUGH A STREAM IN THE SOUTHWEST. BIRDS HAVE INSPIRED POETS AND LOVERS ACROSS ARABIA FOR CENTURIES.

important – that it has recently been inscribed on UNESCO's list of World Heritage sites. Although dating rock engravings is one of the greatest challenges in modern archaeology, there is little doubt that these carvings are well over 10,000 years old. In other words, for as long as there has been art in Arabia, Arabs have celebrated birds.

Images of ostrich and other birds are also common on rocks at the site of as-Suwaydirah, 70 kilometers east of Medina. These images were carved around 9,000 years ago. A similar panel at Qaryat al-Asba (140 kilometers west of Riyadh) contains an extraordinary assemblage of hundreds of animals carved into the rock, including lions, oryx and ibex, as well as human skeletons, battle scenes and numerous designs that appear to be tribal symbols. Dominating one such panel is a magnificent engraving of an adult ostrich standing beside 11 juveniles, which accurately reflects the large clutch size of these enormous birds (the ostrich usually lays up to 11 eggs or sometimes more).[1]

The engravings of ostriches at Bir Hima (30 kilometers northeast of Najran) are the most lifelike in all of Saudi Arabian rock art. Here the birds are depicted with full, fluffy plumage (particularly the tail feathers) in wonderfully realistic postures. Some show ostrich standing upright and still, others depict them in full stride running for their lives as saluki dogs or cheetahs chase after them. In one panel an ostrich is towering over a human figure. In another, an ostrich is surrounded by three hunters on horseback – one hunter has thrust his enormous, sharp spear through the body of the stranded bird.

In fact, images of ostriches can be found all over Saudi Arabia, from Bir Hima in the south, to Tayma in the north, to Qaryat al-Asba in the center of the Kingdom, and many places in between. We can only speculate as to the motive behind these remarkable carvings, though one thing is certain – they are not mere doodles; they are accomplished pieces of art that clearly required considerable skill and time to complete. The artists who created these pieces were certainly motivated. Using crude stone tools, they must have felt a strong desire to painstakingly carve the image of birds in stone. Birds were important to them.

Sometime around 1,500 years ago, Arabian rock art becomes noticeably less abundant. This is probably because the artists of Arabia had learned a new form of expression: poetry... magnificent poetry.

Ancient rock etchings of ostriches can be found all over Saudi Arabia, from Bir Hima in the south, to Tayma in the north, to Qaryat al-Asba in the center of the Kingdom.

ANCIENT ROCK ART AT QARYAT AL-ASBAH DEPICTS TWO ADULT OSTRICH SURROUNDED BY 12 JUVENILES. A LION (DEPICTED WITH A BUSHY TIP ON THE TAIL) PROWLS NEARBY.

IN THE EARLIEST KNOWN ARABIC POEM, IMRU AL-QAYS COMPARES THE PERFECT SKIN OF HIS LOVER TO THE FLAWLESSNESS OF AN OSTRICH'S FIRST EGG.

BIRDS IN ANCIENT ARABIC POETRY

Epic poetry swept through the Arabian Peninsula over 1,500 years ago and has remained a central part of Arab culture ever since. Birds feature regularly throughout this long and grand history. Indeed birds are mentioned in the oldest surviving Arabic poem, which was composed by the legendary Imru al-Qays. His *qaṣīda* (or epic poem) is one of the seven Mu'allaqat poems, which are regarded as the very best pre-Islamic Arabic verse. Imru al-Qays came from Najd where he would have regularly seen ostrich sitting at the nest and attending their eggs, and accordingly in his cherished qaṣīda titled *"Let us stop and weep"*, Imru al-Qays compares the unblemished skin of his long lost love to the flawlessness of an ostrich's first egg:

In complexion she is like the first egg of the ostrich –
White, mixed with yellow.
Pure water,
Unsullied by the descent of many people in it,
Has nourished her.

IMRU AL-QAYS (DEC. 565).
[TRANSL. LYALL 1918]

In another of the Mu'allaqat, 'Abid ibn al-Abras describes his cherished mare, with breathtaking detail, as if she were as fast and powerful as an eagle chasing down a fox:

She is like an eagle, swift to seize her quarry –
– in her nest are the hearts of her victims gathered.
Night-long she stood on a way-mark, still, upright,
like an old woman whose children are all dead;
And at dawn she was there in the piercing cold,
the hoar-frost dropping from her feathers.
Then she spied on the moment a fox far off –
between him and her was a droughty desert:
Then she shook her feathers and stirred herself,
ready to rise and make her swoop.
He raised his tail and quailed as he saw her –
so behaves his kind when fright possesses them:
She rose, and swiftly towards him she sped,
gliding down, making for him her prey.
He creeps, as he spies her coming, on his belly:
his eyes show the whites as they turn towards her.
Then she swoops with him aloft, and casts him headlong,
and the prey beneath her is in pain and anguish,
She dashes him to earth with a violent shock,
and all his face is torn by the stones.
He shrieks – but her talons are in his side:
no help! With her beak she tears his breast...

'ABID IBN AL-ABRAS (DEC. 554)
[TRANSL. LYALL 1918]

It is abundantly clear to any ornithologist reading this superb passage that the poet had an intimate knowledge of eagle behavior – the kind of knowledge you can only get from spending long hours watching and admiring birds.

OVER 1500 YEARS AGO, 'ABID IBN AL-ABRAS DESCRIBED AN EAGLE HUNTING DOWN A DESERT FOX WITH EXQUISITE POETIC VERSE. HERE A WESTERN MARSH-HARRIER CARRIES AWAY ONE OF ITS VICTIMS.

Birds are mentioned in the oldest surviving Arabic poem, which was composed by the legendary Imru al-Qays.

A PIED KINGFISHER (LEFT) PERCHES BESIDE A WHITE-BREASTED KINGFISHER. ANCIENT ARABIC POETS DESCRIBED MORE THAN 70 TYPES OF BIRDS WITHIN THE ARABIAN PENINSULA.

Such understanding and appreciation of bird and animal behavior is a constant theme of early Arabic poetry.

It is difficult to overstate just how important such poetry was in early Arabian culture. As the ninth century art critic Ibn Sallām al-Jumaḥî wrote, poetry was to pre-Islamic Arabs "the register of all they knew, and the utmost compass of their wisdom; with it they began their affairs, and with it they ended them". Poets were the public voice of their tribe. According to the eleventh century writer Ibn Rashiq of Qayrawān, for a tribe "a poet was a defense to the honor of them all, a weapon to ward off insult from their good name, and a means of perpetuating their glorious deeds and of establishing their fame forever". Poetry expressed a tribe's fear and sorrows, their hopes and desires, their wisdom, jokes, stories and joy.[2]

Thus early Arabic poetry provides invaluable information about life in the Arabian Peninsula long before the first written word. It is therefore telling that early Arabic poetry is replete with bird imagery. In fact, a review of the poems composed by over 150 early Arabic poets from the pre-Islamic age till the Abbasid period finds mention of more than 70 identifiable types of birds.[3] Again, when you consider the majesty, beauty and mystery inherent in the birds of Saudi Arabia, it is not at all surprising that so many birds have inspired so much superlative poetry – poetry that has been told and retold for over 60 generations.

Early Arabic poetry was usually constructed as a haunting, evocative montage – layer upon layer of extended similes, often depicting natural events or plants and animals, such as the example of the eagle and the fox presented above. Unfortunately we cannot include many long extracts; instead we present snippets of poems to showcase how well early Arabs understood the diversity of birds and their fascinating behavior, and how they related birds to their own lives.

THE IRIDESCENT BEAUTY OF THE VIOLET-BACKED STARLING CAN LEAVE EVEN POETS SPEECHLESS.

A GREATER SPOTTED EAGLE FEASTS ON A GREATER FLAMINGO. SEEING A POWERFUL BIRD LIKE THIS MUST HAVE LEFT A LASTING IMPRESSION ON ANY PASSING BEDOUIN.

EAGLES, FALCONS AND BUZZARDS: KINGS OF THE DESERT

The eagles, falcons and buzzards feature prominently in early Arabic poetry. They were regarded as "the masters of birds" and as "kings of the desert". In some poems they were said to follow armies to eat the flesh of dead soldiers. For example, in his sixth century poem, *Dividing the Spoils of War*, the Najdi poet Antarah Bin Shaddad exclaimed that while the warrior owned the souls of the people he killed, the birds of prey would soon own their flesh. He also noted with a touch of black humor that the ruthless cavalrymen would soon own the dead men's possessions:

For me, their souls,
The meat for the birds of prey,
The bones for the beast...
The looting for the horsemen

ANTARAH BIN SHADDAD (DEC. 608)

The early Bedouin knew that eagles take prey back to their eyrie to be devoured there: as 'Abid noted poetically, gathered in her nest are the hearts of her prey. The poets correctly identified several different birds of prey in their poems, including the Black Kite, Western Marsh-harrier and Eastern Imperial Eagle. For example, some poets describe the *Sagaa* (the name given to Eastern Imperial Eagles with white in their head feathers) hunting down wolves or foxes, which must have made quite an impression on a poet. This is especially notable given the Eastern Imperial Eagle is a winter visitor to the Kingdom that today arrives in small numbers only.

EURASIAN BUZZARD. FAST AND POWERFUL BIRDS LIKE BUZZARDS, EAGLES AND FALCONS WERE COMMON MOTIFS IN EARLY ARABIC POETRY.

THE OMINOUS SHADOW CAST BY A CRUISING LAPPET-FACED VULTURE CAPTURED THE IMAGINATION OF MANY EARLY POETS.

THE ENDANGERED EGYPTIAN VULTURE WAS KNOWN TO THE EARLY POETS AS AL RAKHAM.

VULTURES: OMINOUS SHADOWS IN THE DESERT

Vultures also feature prominently in Arabic poems with the poets again distinguishing between several different species. In some, the poet compares the great bulk of his she-camel to the ominous shadow cast by an old Lappet-faced Vulture (which was called *Gashaam*, *Labaad* or *Madhrahy*). Other poems mention a brown vulture (called *al-Anoque*), probably the Griffon Vulture, and the white vulture (*al-Rakham*), the Egyptian Vulture.

The early poets used the remote nest of the Griffon Vulture (which lays its eggs in crevices high up in rocky cliffs) as a metaphor for something frustratingly difficult to reach, such as the house of a lover, as Tameem bin Moq'ble lamented humorously:

Alas! Her home is farther than the eggs of a Griffon Vulture
in Raam [the name of a steep mountain]
Beyond layer upon layer of rough muddy sand
in al-Bareque! [a remote place in the 'Asir Mountains]

TAMEEM BIN MOQ'BLE (DEC. 679)

It is indeed difficult to imagine something less accessible than the eggs of a menacingly huge bird, laid high in a cliff, beyond miles of heaping sand dunes, on a prominent mountain, deep in the rugged 'Asir Mountains! This well-known Arabic proverb (more unreachable than the eggs of a vulture) is still in use today.

AN EXCEPTIONALLY REMOTE NEST OF A GRIFFON VULTURE ON A PRECIPITOUS CLIFF FACE NEAR TANUMAH. THIS IS THE STUFF OF LEGENDS.

LICHTENSTEIN'S SANDGROUSE – ONE OF AT LEAST THREE SANDGROUSE SPECIES IDENTIFIED AND DESCRIBED BY EARLY ARABIC POETS.

SANDGROUSE: ACHING FOR WATER IN A SEA OF SAND

Other common birds in Arabic poetry include sandgrouse, which are depicted in detail with remarkable accuracy. Impressively, the poets distinguished between at least three of the six sandgrouse species found in Saudi Arabia: they mention Lichtenstein's Sandgrouse, *al-Qata Elcodri*, with its dusty color, mottled back and belly, yellow throat and short tail; Black-bellied Sandgrouse, *al-Qata Aljoni*, with its black belly and wings, and pinions with short tails; and the Crowned Sandgrouse, *al-Qata Ghatat*, with its dusty-colored back, belly and chest, black wing tips, and long legs and neck.

The Bedouin knew that sandgrouse rarely drink, but when they do they often fly in large flocks to drink in the morning or at night. Some poets, such as 'Abid ibn al-'Abras (dec. 554), claimed his horse was faster than a thirsty sandgrouse racing to a pool of water. Further, they knew that sandgrouse nested in hollows in the ground and that nesting sandgrouse have developed an unusual behavior for hydrating their chicks: the adults fly quickly from their nest to a pool, dip their breast feathers in the water, and then race back to the nest to allow the chicks to drink the water that still clings to their plumage. The Bedouin knowledge of sandgrouse is all the more impressive when you consider they did not have binoculars. Toward the end of the sixth century, al-Muthaqqib noted that his thirsty she-camel would rest her chest in a pool of water much like a brooding sandgrouse:

The hollows in the ground where she sets her callouses [i.e., rests]
are like the settling-places of the black-backed sandgrouse
that come in the early dawn to drink.
When she takes a deep breath and so fills her chest,
it almost cuts through the plaited strands

AL-MUTHAQQIB (AROUND 580)
[TRANSLATED BY LYALL 1918]

PIGEONS AND DOVES: COO TO COMFORT ME

Pigeons and doves are very common images used in early Arabic poetry. Their mournful bewailing on the branches of trees reminded poets of their loved ones, and still does today. Again, the poets had a clear knowledge of the different types of pigeons and doves in Arabia. For example, in his moving verse from the Umayyad period, Nabiq'a Bani Shaiban uses the constant calling of African Collared-doves as a symbol of the perpetual chastity of his lover:

She kept it away from a thirsty man even if he dies
As long as the collared-doves sing a song

NABIQ'A BANI SHAIBAN (DEC. 743)

PIN-TAILED SANDGROUSE. EARLY ARAB POETS REVERED SANDGROUSE FOR THEIR ABILITY TO TRAVEL LONG DISTANCES TO FIND WATER.

NAMAQUA DOVE. DOVES AND PIGEONS WERE COMMON SYMBOLS IN EARLY ARABIC POETRY.

THE REPEATED, MOURNFUL CALL OF THE LAUGHING DOVE HAS REMINDED MANY A BROKEN-HEARTED POET OF THEIR LONG LOST LOVE.

Rock Doves (the common pigeon), often called *Warqua* in Arabic poetry, were sometimes mentioned as the grey pigeons that nest on the balconies of palaces, probably as a lyrical way of displaying stability and thus wealth.

With balconies, unreachable for birds,
Though, there you can see the nests of grey pigeons

AL-A'SHA (DEC. 629)

The gentle, mournful call of the Laughing Dove (known as *al-Gamari* or *al-Fawakhet*) certainly lends itself to poetry and was thus a common metaphor. In the Abbasid period, the poet ar-Roumi compared the soft voice of his beloved with the sound of the Laughing Dove's call:

She is a gazelle, inhabiting the heart
She is a Laughing Dove singing a song

AR-ROUMI (DEC. 896)

Likewise a heart-broken Majnoon Laila found solace in listening to a pair of doves, before lamenting:

O, the two doves
Reply to each other's melody,
Then coo to comfort me

MAJNOON LAILA (DEC. 687)

CROWS AND OWLS: BIRDS OF ILL FORTUNE

Interestingly, some birds were not regarded fondly, particularly the crows (i.e., ravens) and owls. Crows are much maligned in many parts of the world. Some of this criticism derives from the belief that crows kill livestock, particularly sheep and goat. Some people see a crow eating a carcass and assume they must have killed it; but in fact crows usually only eat the bodies of already-dead animals. Although people may find the idea of a crow (or a vulture) eating a carcass distasteful, these birds nonetheless play an important role in the ecosystem by helping to remove dead animals from the landscape, which would otherwise rot, smell and spread disease. Regardless, these large, jet-black birds with their reputation for killing other animals were a poetic goldmine.

Accordingly, in Arabic poetry the Brown-necked and Fan-tailed Ravens are generally associated with misfortune, feeding on the soft parts of corpses, such as the eyes. They received many names in Arabic poetry, including Wilderness Crow (*ghorab alfala*) (reflecting their ability to live and nest in even the deepest desert), Black Crow, Departure Crow and the Bird of Misfortune. Some poets cursed ravens, claiming they were the cause of their lover departing:

Are you shedding tears
because of the whooping of crows in the morning?
O crow of parting, may you shout not;
May a slayer get your throat veins.
The hearts of mad lovers are horrified
when they hear your shouting

MAJNOON LAILA (DEC. 687)

Although the owl is typically used as a symbol of wisdom in the west, in Arabic poetry it often had negative connotations.[4] For example, it was used as a symbol for a weak man, or its shrieking call was compared to the wailing of a mother who had lost her only child. In other poems, the barking or shrieking of an owl indicated menacing wilderness:

Fearful wasteland where the female owl replies to the male
Awesome, when the night goes darker

'ABID IBN AL-'ABRAS (DEC. 554)

In some poems, the owl was intimately associated with death and vengeance and used skillfully by some poets to graphically depict the gruesome aspect of combat:

In every valley between Yathrib and al-Qusur, as far as al-Yamamah
Is the ululating of a captive,
The screaming of a burnt man,
Or the voice of an owl

'ABID IBN AL-'ABRAS (DEC. 554)
[TRANSL. BY LYALL 1913]

BIRDS AND THE AGONY OF LOST LOVE

It is clear that Arabic poets had not only an intimate knowledge of birds, but also a deep respect and admiration for them. Many saw the intrinsic beauty and elegance of birds as metaphors for the beauty of their lovers:

She has no flaw, while her eyes are blue
Similarly, the eyes of the bird masters [i.e., eagles] are blue

ABU AL-ASWWAD AL-DOE'LY (DEC. 688)

THE LITTLE OWL HAS THE REMARKABLE ABILITY TO FIND FOOD IN ALMOST TOTAL DARKNESS. NO WONDER OWLS FEATURED PROMINENTLY IN ANCIENT ARABIC POETRY AND FOLKLORE.

THE BREATH-TAKING SHORT-EARED OWL, SURELY ONE OF THE MOST SPECTACULAR BIRDS IN SAUDI ARABIA.

She dropped her eyelids shyly
As a bustard while falcons are flying around

ABU THOIAB AL-HOTHALY (DEC. 648)

Some poets compared the marvelous swift flight of birds to the speed of their all-important she-camels:

My she-camel flies as a vulture
When the wind is helpful

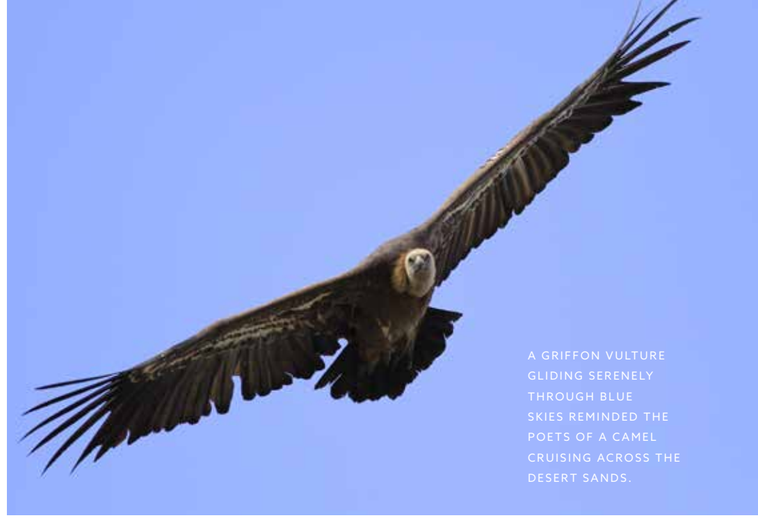
TAMEEM BIN MOQ'BLE (DEC. 657)

The flight of a vulture is a strong metaphor for the smooth and swift movement of a camel. Vultures rarely flap their wings in flight; instead they move both rapidly and serenely through the air in seemingly effortless bursts of soaring and gliding flight – just the qualities a Bedouin would admire in a camel.

Other poets compared the speed and endurance of birds to their most valued possession of all, their horse, which was critical in both hunting and warfare. The father of Arabic Poetry, Imru al-Qays, described riding his prized mare:

As if I am riding a fast-hunting, supple-winged eagle
When shaking my legs upon my horse

IMRU AL-QAYS (DEC. 565)



A GRIFFON VULTURE GLIDING SERENELY THROUGH BLUE SKIES REMINDED THE POETS OF A CAMEL CRUISING ACROSS THE DESERT SANDS.

Similarly, al-Harith son of Hillizah of Yakshur:

My horse is like a hawk
driving before him a pack of doves to the box-thorn bush;
As a hawk that hunts with his talons, deft on the wing to strike:
when he clutches once in his swoop a dove, she moves no more!

AL-HARITH (SIXTH CENTURY)
[TRANSLATED BY LYALL 1918]

In one outstanding passage, Zuhayr ibn Abi Sulma compares the speed of his horse to that of a startled sandgrouse, which – already nervous from having lost its sister – is fleeing from a wild falcon in full flight:

THE PIERCING STARE OF AN OWL HAS STIRRED MANY MENACING THOUGHTS.

She is like one of the sandgrouse that drink at the wells,
Frightened away by those who come to water,
And which nets have already separated from her sister.
Dusky, with a sheen like a gleaming water-pebble...
On it swoops a falcon with cheek feathers suffused with red,
Its fore-feathers lying lightly over one another,
A bird for which traps have never been set...
The two flew from high in the sky to low above the earth,
The falcon at the grouse's tail,
No escape for one, but no overtaking for the other.
With the falcon at its tail the grouse cries and squawks;
Sometimes the falcon almost seizes it, sometimes it speeds away.

ZUHAYR IBN ABI SULMA (SIXTH CENTURY)
[TRANSL. BY JONES 2011]

In perhaps the greatest display of admiration, some of the poets even *envied* birds, particularly their incredible ability to fly and the freedom it bestows. Here the pre-Islamic poet Tarafa ibn al-'Abd envied the curlews. Stranded on a slow-moving horse in the desert, the poet reasoned that although curlews may be perpetually chased by falcons, at least they can fly:

We own a day,
So do curlew birds.
The miserable fly
But we cannot.
Their day is ominous –
Always chased by falcons!
Our day, what a day...
Riding on motionless horses;
Neither arriving,
Nor moving on.

TARAFA IBN AL-'ABD (DEC. 569)

EURASIAN CURLEW. 'WE OWN A DAY, SO DO CURLEW BIRDS', SO SAID TARAFA IBN ALABD OVER 1400 YEARS AGO.

Interestingly, early Arabic poets were not afraid to portray animals as feeling emotions. For example, in the poem by 'Abid ibn al-Abras (detailed above) the fox is clearly depicted as feeling fear. Attributing emotions to animals is normally considered to be a relatively modern phenomenon, but it is a well-developed feature of Arabic poetry.[5] It is regarded technically as the highest level of expression of beauty, and is yet another way in which the early poets showed their deep connection with birds. For example, while imprisoned by the Byzantines Abu Firas al-Hamadani saw a dove standing in the window of his cell. After hearing its melancholy call he began speaking to the dove to see if it too was weeping from heartache:

When a dove wept beside me, I asked,
"Do you feel what I am feeling?"
But you never went through the agonies of love;
The departure of your lover
Had not even passed by your imagination.
Does a captive laugh
Whilst the free cries?
My eyes are more deserving of tears than yours
But my tears in calamities are scarce.

ABU FIRAS AL-HAMADANI (DEC. 979)

Oh, what exquisite imagery.

THE ONCE COMMON OSTRICH: AL-HAYA NO MORE

The species most frequently mentioned in early Arabic poetry is the Common Ostrich. Of the 150 poets reviewed in this analysis, 26 mention ostrich in over 50 different poems. The ancient poets clearly admired this enormous bird. Its amazing running speed, which can exceed 70 kilometers per hour, was often compared to the speed of the she-camel or horse. In other poems, the billowing black and white plumage of the male was likened to oncoming rain clouds, while the curving neck was said to resemble the curve of a bow. Underlining how well the ancient Bedouin knew and appreciated these birds, it was known by more than 130 different names usually based on its distinctive appearance or behavior (*see* Table 1).

Using graceful verse, the poets explain accurately that the ostrich can obtain all the water it needs from the plants it eats, which plants it prefers to eat, its habitat, nest shape, clutch size, chick-rearing behavior, sexual dimorphism, vigilance, molting, foraging techniques, gregariousness, vocalizations, and anti-predator strategies, among many other behavioral traits, many of which were not known to western science until the second half of the twentieth century.

A poem by al-A'asha includes a typical example of how well the Bedouin understood bird behavior. Ostrich usually nest as a solitary pair, or in a group comprising a territorial male, one primary female and one or more secondary females, which share the same nest. The primary female usually lays up to 11 eggs, whereas the secondary females lay only two to six eggs.[6] In this passage, al-A'asha alludes to the drab-grey secondary female trying to assert herself within the group, perhaps seeking status as the primary female:

A WHITE-BREASTED KINGFISHER STARES INTENTLY AT A WETLAND BELOW. INTERESTINGLY, EARLY ARABIC POETS WERE NOT AFRAID TO PORTRAY ANIMALS AS FEELING EMOTIONS.

TABLE 1: A SMALL SAMPLE OF THE 130 NAMES FOR OSTRICH USED IN ANCIENT ARABIC POETRY.

ARABIC NAME	MEANING	NOTES
al-Ajfal	Scared easily	Ostrich can run for many kilometers when threatened
al-Akhraj	Black and white	Ostrich have black and white plumage
al-Asak	Bare shank	Ostrich have quite bare shanks
al-Azar	Featherless	Ostrich have quite bare legs and neck
al-Hayg	Huge	Ostrich stand up to 275 cm tall and weigh 90–156 kg making them the largest bird in the world
al-Khadhb	Henna	Arabian ostrich males had red neck and legs (particularly when breeding) as if rouged with henna
al-Sa'al	Small head	Ostrich head is tiny compared to the body
al-Shawh	Ugly one	Although beauty is in the eye of the beholder, ostrich are not exactly known for their piercing good looks
al-Thaleem	Black	Arabian ostrich males had darker, black feathers compared to the female
al-Zafoof	Fast	Ostriches are the fastest land birds on earth, able to exceed 70 km/h
Hagfan	Rough and coarse with thick feathers	Ostrich plumage is very thick with some feathers exceeding 50 cm
Mehar	The male whose feathers fall in summer	Ostrich molt in summer at the end of the breeding season
Nagnag	The sound of the beak clapping	Ostrich clap their beak as a signal when threatened

BRUCE'S GREEN-PIGEON, ONE OF THE WORLD'S PRETTIEST PIGEONS. NO WONDER BIRDS ARE REGULARLY USED AS SYMBOLS IN ARABIC POETRY.

Small-headed ostrich with thick grey dusty feathers at al-Garatain
Went in the evening following its male,
As if challenging the grey female
In a group of ostrich

AL-A'ASHA (DEC. 629)

In an extended passage from the enigmatic 'al-Qamah bin 'Abadah, constructed over 1,400 years ago, the poet insightfully describes the ostrich's appearance and foraging behavior, as well as its unusual paternal care and communal breeding biology.

Like a male ostrich, with legs colored red
and scanty down on his fore wing-feathers,
to whom along the margins of the sand dunes
the colocynth and the tannum have ripened.

He spends the day among the colocynths
streaked with green and yellow,
breaking them open to extract the seeds,
and he nips off that which shoots up above ground of the tannum.

His mouth is like a split in a stick –
hardly canst thou discern the cleft:
he is small in that wherewith he hears sounds [i.e., its ear],
as though it were cut off at the root...

A fleet runner is he:
his breast is like the wooden frame of a lyre:
he looks like a water-bird [flying down with outstretched neck]
to pools in moist meadows.

He is making for a brood of nestlings with little hair on their crops:
when they crouch together in the nest,
they look like the roots of trees
with dust gathered about them by the wind.

ANCIENT ARABIC POETS HAD OVER 130 NAMES FOR THE COMMON OSTRICH, EACH DESCRIBING A DIFFERENT ASPECT OF THE APPEARANCE OR BEHAVIOR OF THESE COLOSSAL BIRDS.

OSTRICH AT SHAYBAH WILDLIFE SANCTUARY. ANCIENT ARABIC POETS ACCURATELY DESCRIBED MANY ASPECTS OF OSTRICH BEHAVIOR – ALL IN SUBLIME VERSE.

Till at last he attains,
while the Sun's limb is still high,
to the nest of two spouses,
wherein are the eggs arranged close together...

Small is his head,
set on a slender neck,
and his wings and breast are like a tent fallen down,
about which a clumsy handmaid busies herself.

There comes round about him his mate,
long-necked, bending down her head,
who answers him with a murmuring note
wherein is a trill.

'AL-QAMAH BIN 'ABADAH (SIXTH CENTURY)
[TRANSLATED BY LYALL 1918]

A FALCONER'S PRIZED SAKER FALCON IN FLIGHT.

It is sobering to think that a bird that was intimately known to early Bedouins and so much a part of Arabian life for millennia is now extinct in the wild. Equally sobering, most people in Saudi Arabia today do not even know that the Common Ostrich ever occurred in the Arabian Peninsula.

FALCONRY

The oldest known sport, falconry, is intimately connected with the birds of Arabia. Exactly where and when it began is unclear, but archaeological evidence provides some tantalizing clues that it is indeed an ancient practice. For instance, 12,000–year-old cave art in central Iran depicts a hunter riding a horse, with a hunting dog by his side and a large, sleek bird standing on his fist, perhaps indicating falconry. Likewise, recent excavations from ancient Sumer (a culture that extended into Eastern Arabia) uncovered 9,000-year-old burial sites containing hunting dogs lying alongside falcons, which were presumably for hunting.

While these discoveries are suggestive of falconry, the oldest unequivocal evidence for this ancient pursuit comes from Tell Chuera in Syria, a site that lies within the same basalt desert that stretches south to Saudi Arabia. The artwork on a 5,000-year-old shard of pottery depicts a raptor standing atop the fist of a man; significantly, the bird has captured prey and is wearing leather jesses (leg straps) typical of modern Arab falconers.[7] Falconry has remained an important aspect of Arabian culture ever since.

From 3500 BCE, there are early references to hunting with birds from the al-Rafidein region of Iraq. By 1700 BCE, wall hangings, bas-reliefs, and pictorial records indicate Arabian falconry was widespread.[8] By the fourth century, we find the written descriptions of famous Arabian people training and using falcons, specifically al-Harith bin Mu'awiya bin Thawr al-Kindi, the king of an area that included part of modern day Saudi Arabia. Many stories are told of the ancient ruling house of al-Araiar, the hereditary sheikhs of the Bani Khalid in Hasa and Najd, which encouraged the sport and preserved game for falconry's sake.[9]

Falcons and falconry continued to be depicted prominently in Umayyad and Abbasid art and culture, including on early Umayyad coins.[10] For the Umayyad Caliph Yazid Bin Mu'wiya, who came to rule in 680, hunting with falcons and trained cheetahs was his passion; he had special houses built for his falcons and developed Arabian falconry into a highly organized sport. Around 710, Adham bin Mehrez al-Baheli wrote his classic text *The Advantages of Birds*, which is the first book ever written about falconry. Technical knowledge of falconry was then transmitted to Europe through the spread of Islam where it soon became a sport of the elite.[11]

The Arabian fascination with falconry continued into the medieval period. Around 1150 we find written descriptions of hunting for houbara bustards with falcons, such as the chronicles of the medieval Muslim poet, author, *faris* (knight) and diplomat, Usama ibn Munqidh (1095–1188), and it is clear from European records that falconry had become the dominant desert sport among Arabs by the eleventh century.[12] Clearly falconry and the lore of falcons are deeply ingrained in Arab traditions and culture, and falcons continue to have a central and respected place in Arabian society and culture.

The long history of falconry in Arabia underpinned UNESCO's decision in 2012 to inscribe falconry in Saudi Arabia and 12 other nations on the list of humanity's *Intangible Cultural Heritage*. Falconry is therefore recognized internationally as part of our shared cultural heritage – a social tradition respecting nature and the environment, passed on from generation to generation, and providing a sense of belonging, continuity and identity. UNESCO identified that "falconers develop a strong relationship and spiritual bond with their birds, and commitment is required to breed, train, handle and fly the falcons." It is now considered a symbol of Arabian culture and tradition.

GOLDEN EAGLES HAVE BEEN TRAINED FOR HUNTING FOR CENTURIES IN ARABIA.

The oldest known sport, falconry, may date back 12,000 years or more. It has remained an important aspect of Arabian culture ever since.

THE LANNER FALCON HAS BEEN USED IN FALCONRY FOR MILLENNIA, BUT IT IS NOW CRITICALLY ENDANGERED IN ARABIA.

THE SAKER FALCON IS ONE OF THE MOST ICONIC BIRDS OF ARABIA, BUT NOW IT IS AT RISK OF EXTINCTION.

IS MODERN FALCONRY SUSTAINABLE?

In Saudi Arabia, three species of falcons are primarily used for falconry: Saker, Lanner and Peregrine (including Barbary) falcons. Unfortunately all of these birds are now exceedingly rare in the region. Hence the question, is modern falconry sustainable?

Traditional Arabian falconry requires great patience, ingenuity and sensitivity. Bedouins would trap, train, and hunt with migratory falcons during the winter months in order to supplement their diet and for recreation. It usually took weeks to catch a wild falcon by hand, and two or three more weeks to train it. In early spring, the falcon was released to resume its natural migratory behavior.

Most falcons were not disadvantaged by this practice. For example, a falconer who captured a Peregrine Falcon at Yanbu' in 2011 accidentally released his bird while hunting south of al-Wajh in Tabuk Province. The bird was captured 12 months later breeding in the far north coast of Russia where it continued to breed for several years. Indeed, some researchers suggest that birds used for falconry may even have benefitted from traditional falconry through increased survival rates over their first winter.[13]

Today, most Arab falconers keep their falcons in air-conditioned rooms or in free-flying aviaries during the summer so that they can be used again for the next season. As a result, increasingly few falcons are given the chance to migrate and breed in the wild. Sadly, medical records reveal that in Riyadh alone more than 2,000 captive falcons are treated *every year* for infectious diseases (especially Newcastle disease), traumatic injuries, toxicosis and metabolic or nutritional diseases.[14] Further, the high price paid for young falcons means that unsustainably high numbers of wild birds are being captured all year round. For instance, on average an estimated 34 Saker Falcons and 180 Peregrine Falcons are trapped in Saudi Arabia every year, with the numbers increasing steadily.[15] Birds are also captured at remote breeding areas throughout Eurasia, particularly central and northern Asia (and are then smuggled into Arabia, often with poor outcomes for the birds), which further threatens falcon populations.[16]

Given the significance of falconry in Arabian culture and their important role in the ecosystem, it is imperative that falcons are protected.

THE ASIAN HOUBARA BUSTARD IS NOW CRITICALLY ENDANGERED IN ARABIA, LARGELY DUE TO OVER HUNTING.

THE PEREGRINE FALCON IS INCREASING GLOBALLY AFTER RECOVERING FROM THE IMPACTS OF DDT POISONING. UNFORTUNATELY IT IS STILL ENDANGERED WITHIN ARABIA.

This suggests some modern falconry practices are now contributing to the demise of some of the most iconic species in the Kingdom. Regionally, Peregrine Falcons are endangered, while Lanner Falcons and Saker falcons – the quintessential birds of Arabian falconry – are both critically endangered and decreasing. Not only that, the species that are traditionally targeted by falconers, namely Asian Houbara, Eurasian Thick-knee and Cape Hare, are also becoming increasingly rare, particularly Asian Houbara, which is now critically endangered within the region. If these declines continue, we will no longer see *any* wild falcons (or Houbara) in the Kingdom. Given the significance of falconry in Arabian culture and their important role in the ecosystem, it is imperative that these species are protected.

Some scientists have proposed projects to trap first-year passage migrants in fall, train and fly them in falconry during fall and winter, and then release them back to the wild at the time of spring migration, as a way to increase first-year winter survival above that occurring in nature.[17] In other words, by reverting to traditional Arabian falconry practices, we may be able to help restore populations of these magnificent birds and elevate the grandeur of the sport. It seems that modern science is indicating that the old time Bedouin falconers knew best how to protect their birds and their environment.

BIRDS IN ISLAM

Birds are mentioned in the Qur'an on 20 occasions. They appear in episodes in the life of Abraham, Joseph, David, Solomon and Jesus. The Prophet Muhammad taught that Muslims should act kindly towards all living beings, including birds. For example, he commanded that birds' nests should not be disturbed and that the eggs or chicks should not be stolen. Once he ordered a man who had taken fledglings from their nests to return them immediately. Furthermore, he said: "If without good reason anyone kills a sparrow, or a creature lesser than that even, the living creature will put his complaint to God on the Day of Judgment, saying: 'So-and-so killed me for no purpose'" (Nasai, Sayd, 34).

Birds are mentioned in the Qur'an on 20 occasions where they display the ability and power of God.

Birds are used to confirm the magnificence of God's creation, either through the miracles provided to the prophets or to remind humans of His ability and power. For example, when talking to Jesus the ability of birds to fly is mentioned alongside other miracles including healing the sick, curing blindness and bringing the dead to life:

THE BRILLIANT AZURE FEATHERS OF A COMMON KINGFISHER. IT IS NO WONDER THAT BIRDS ARE MENTIONED IN THE HOLY QU'RAN NO LESS THAN 20 TIMES.

THREE BIRD SPECIES ARE SPECIFICALLY MENTIONED IN THE HOLY QU'RAN, INCLUDING THE FAN-TAILED RAVEN.

"I have come to you with a sign from your Lord, that I design for you out of clay, as it were, the figure of a bird, and breathe into it, and it becomes a bird with Allah's permission; and I heal him who was born blind, and the leper, and I bring the dead to life with Allah's permission. And I inform you of what you eat, and what you store in your houses. Surely, therein is a sign for you, if you believe."

SURAT AL-MAAIDAH 110

Three birds are mentioned in the Qur'an by their specific name: the Fan-tailed Raven (*Ghurab*), the Common Hoopoe (*Hud Hud*), and the Common Quail (*Salwa*). God sent the raven to the Sons of Adam to show him how to bury their dead after the first murder on the face of the earth:

Then Allah sent a crow searching in the ground to show him how to hide the disgrace of his brother. He said, "O woe to me! Have I failed to be like this crow and hide the body of my brother?" And he became of the regretful.

SURAT AL-MAAIDAH 31

The Common Hoopoe is mentioned in relation to the Prophet Solomon to give another lesson to humanity in courage and faith: the Hoopoe shows great courage when it sat near the Prophet Solomon knowing that it could be punished for its delay, and great faith when at the end of his story he states "Allah – there is no deity except Him, Lord of the Great Throne". This story also provides an early reference that the Hoopoe can migrate between Palestine and Yemen:

He inspected the birds, and said: "What is the matter that I see not the hoopoe? Or is he among the absentees? I will surely punish him with a severe torment, or slaughter him, unless he brings me a clear reason."

But the hoopoe stayed away not long, he [came up and] said: "I have grasped [the knowledge of a thing] which you have not grasped and I have come to you from Sheba [in Yemen] with true news. I found a woman ruling over them [the Queen of Sheba], and she has been given all things that could be possessed by any ruler of the earth, and she has a great throne. I found her and her people worshipping the sun instead of Allah..."

SORAT AL-NAML 2026

THE INCOMPARABLE COMMON HOOPOE IS CITED IN THE QU'RAN TO TEACH A LESSON IN COURAGE AND FAITH.

Finally, the Common Quail is mentioned to display one of God's miracles.

We delivered you from your enemy, and we made an appointment with you at the right side of the mount, and we sent down to you manna and quails.

SORAT TAHA 80

Birds are mentioned in the Qur'an to display the ability and power of God. One example is the story of the army of elephants, which came from Yemen under the command of Abrahah al-Ashram, to destroy the Ka'bah in the Holy Mosque at Makkah. According to Islamic sources, the elephants refused to march on the Ka'bah, despite being whipped, and the army was then miraculously destroyed by a flock of birds that filled the sky and pelted the men with stones:

Have you [Oh Muhammad] not seen how your Lord dealt with the companions of the elephant? Did He not disrupt their plans, and send against them birds, in flocks, striking them with hard clay stones; leaving them like a field of grazed crops?

AYAH AL-FIL 105:1

In this instance, the birds are referred to as "*at-tayer al-ababel*", which means simply "birds

THE COMMON QUAIL IS REVEALED IN THE QU'RAN AS AN EXAMPLE OF ONE OF ALLAH'S MIRACLES.

A BLACKSTART IN FLIGHT. THE QUR'AN INVITED HUMANS TO SEE ALLAH IN THE MIRACLE OF BIRD FLIGHT.

in large flocks". Some authors suggest this refers to large flocks of swallows or swifts; however, no detail is mentioned in any of the trusted literature about the particular species of these birds.

Finally, Allah asked humans to know Him through bird flight, by observing how they fly and move their wings:

Do they not see the birds above them, spreading out their wings and folding them in? None upholds them [aloft] except the Most Beneficent [Allah]. Verily, He sees everything.

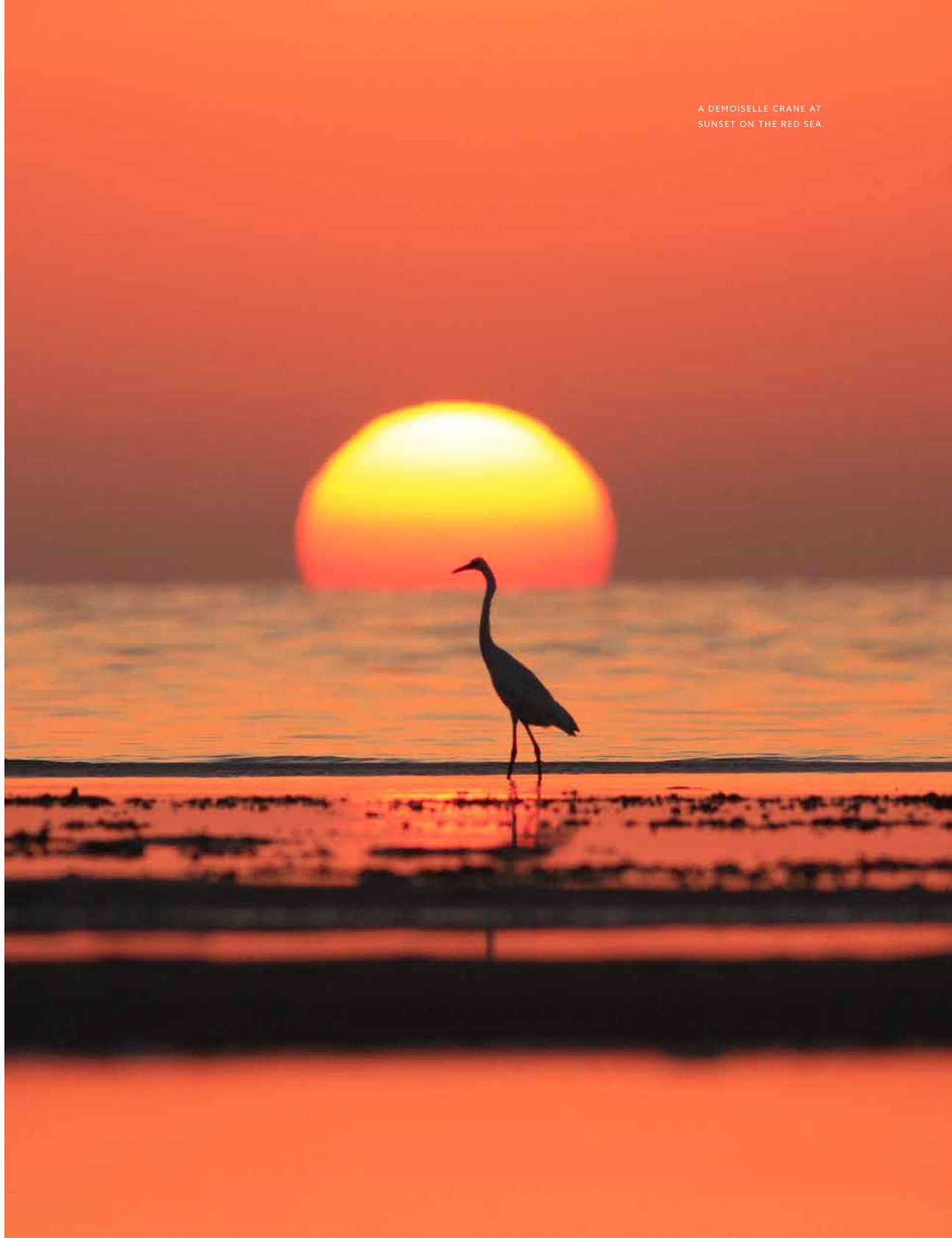
SORAT I-MULK 67:19

By studying and understanding birds perhaps we will better understand ourselves.

CONCLUSION

Birds in Arabic art, poetry, song, speech and sport demonstrate how the beauty of birds has pervaded our consciousness, perhaps more than we realize. They are as much a part of our inner world as they are a part of the outer world. In Saudi Arabia the decline of some bird species (*see* Chapter 1) represents a loss of not only our natural heritage, but also our cultural heritage. It not only takes something special away from the ecosystem, it takes something special away from us.

A GRACEFUL PRINIA BURSTS FORTH WITH SONG, BRINGING JOY TO ALL THOSE LUCKY ENOUGH TO LISTEN.



A DEMOISELLE CRANE AT SUNSET ON THE RED SEA.

A SQUACCO HERON DEVOURS AN INTRODUCED TILAPIA FISH AT A WETLAND NEAR JUBAIL.

CHAPTER 3

How Ecosystem Diversity Affects the Birds of Saudi Arabia

KEY POINTS

- A journey across Saudi Arabia reveals a surprising diversity of ecosystems, with each ecosystem containing a different collection of birds.
- The greatest diversity of birds is found in the southwest highlands and along the coasts.
- The highest density of birds is found on offshore islands.
- Arabian endemic species occur more often in the west and southwest, particularly in the highlands.
- The increase in artificial wetlands, agricultural landscapes, and urban and residential areas has resulted in dramatic changes to the number and diversity of birds in Saudi Arabia.
- Saudi Arabia contains 39 internationally recognized *Important Bird and Biodiversity Areas* distributed across the Kingdom, covering over 46,500 square kilometers or 2% of Saudi Arabia's land mass.

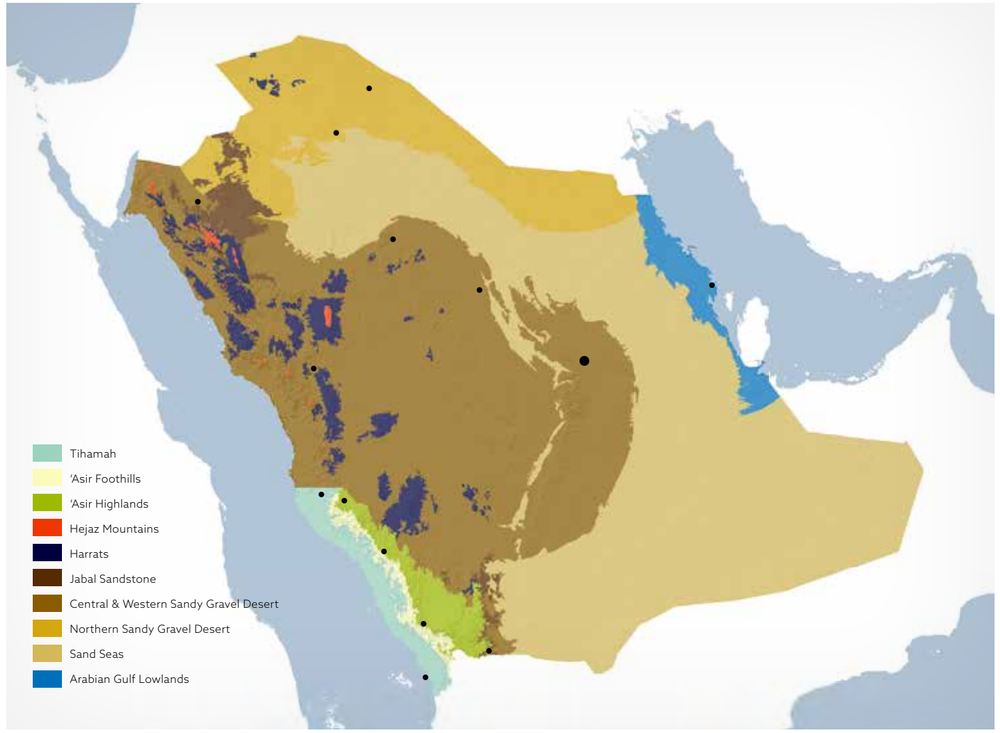


FIGURE 1: MAJOR AVIFAUNAL REGIONS OF SAUDI ARABIA. EACH REGION HAS ITS OWN ASSEMBLAGE OF BIRDS DUE TO DIFFERENCES IN LOCAL CLIMATE, HABITATS, LANDSCAPE FEATURES, AND BIOGEOGRAPHY.

THE BROWN WOODLAND-WARBLER IS CONFINED TO THE 'ASIR HIGHLANDS ABOVE 1800 M.

A LAND OF SURREAL SCENERY

Saudi Arabia is a land of surreal scenery, stunning contrasts, and surprising biodiversity. In this chapter we will take a journey across the Kingdom, traveling from west to east, from the Red Sea to the Arabian Gulf. We will encounter tropical islands, coastlines, mountains, forests, grasslands, lava fields, gravel deserts and sand seas. We will see that bird diversity changes (sometimes subtly, sometimes dramatically) as we pass through these various ecosystems. We will also notice how artificial ecosystems – particularly our cities, our farms, and our wetlands – are dramatically changing the diversity, distribution and abundance of birds within the amazing landscape of Saudi Arabia.

RED SEA ISLANDS

We begin our journey off the west coast of Saudi Arabia, in the stunning tropical blue waters of the Red Sea. Very few people realize that more than 1,300 islands in the Red Sea belong to Saudi Arabia. Many of these islands are astonishingly beautiful – especially when teeming with thousands of breeding birds.

Although most Red Sea islands are simple, low-lying, sandy-shored islets, they nonetheless provide exceptionally important breeding habitat for many birds. Indeed the highest concentrations of breeding birds anywhere in Saudi Arabia occur on offshore islands in both the Red Sea and the Arabian Gulf each spring and summer. Almost a quarter of a million pairs of birds from 23 species nest every year on Saudi Arabian islands (*see* Table 1). Although these islands account for only 0.05% of the Kingdom's total land mass, almost 1% of Saudi Arabia's roughly 27 million annual breeding pairs nest on those small islands. In other words, the islands of Saudi Arabia contain 20 times the average nesting density of the rest of Saudi Arabia.

There are two main reasons why so many birds nest on offshore islands. First, since most islands are isolated from the mainland, they tend to be inaccessible to terrestrial predators such as cats, dogs, foxes, rats and monitor lizards. An island free of ground predators is a particularly attractive place to build a nest, especially for ground-nesting species like most seabirds.

More than 1,300 islands in the Red Sea belong to Saudi Arabia. Many of these islands are astonishingly beautiful – especially when teeming with thousands of breeding birds.

MANGROVE TREES ON FARASAN ISLAND. MORE THAN 1300 ISLANDS IN THE RED SEA BELONG TO SAUDI ARABIA, WITH SOME CONTAINING THOUSANDS OF NESTING BIRDS.

THE CASPIAN TERN BREEDS ON SMALL, UNINHABITED ISLANDS IN THE RED SEA.

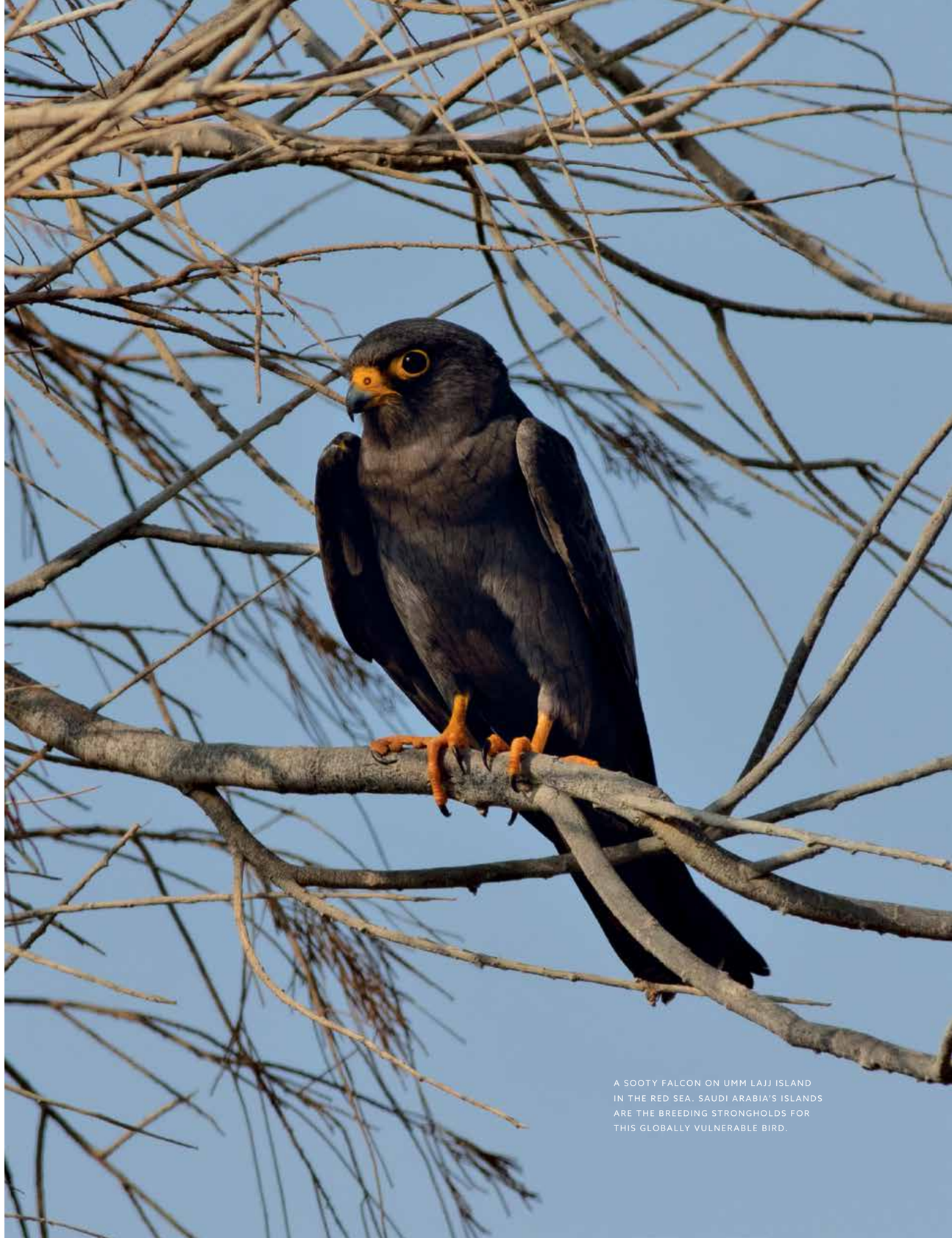
BROWN BOOBY BIRDS NEST ON SEVERAL ISLANDS IN THE RED SEA.

Second, by definition, seabirds obtain their food from the sea, not the land; therefore seabirds only need the island to provide sufficient *physical space* in which to build a nest. As a result, dense colonies of seabirds can form on suitable islands with each nest built sometimes only centimeters from neighboring nests. These birds usually time their nest cycle to coincide with the annual peak in marine productivity, and then leave the island to spend the rest of the year foraging at sea. Thus, seabird islands can be a hive of breeding activity in summer and then fall eerily silent by autumn.

Islands in the Red Sea provide very important nesting habitat for 20 species, including eight species that breed nowhere else within Saudi Arabia (*see* Table 1). Very large numbers

TABLE 1: SAUDI ARABIAN BREEDING LOCATIONS OF BIRD SPECIES THAT NEST PRIMARILY ON ISLANDS.

COMMON NAME	RED SEA ISLANDS	RED SEA COAST	ARABIAN GULF COAST	ARABIAN GULF ISLANDS	ESTIMATED BREEDING PAIRS
Brown Booby	✓				5,000
Brown Noddy	✓				7,200
Crab-plover	✓				1,400
Eurasian Spoonbill	✓				150
Goliath Heron	✓				60
Pink-backed Pelican	✓				400
Sooty Gull	✓				1,500
White-eyed Gull	✓				3,000
Collared Kingfisher	✓	✓			300
Green-backed Heron	✓	✓			1,000
Sooty Falcon	✓	✓			300
Caspian Tern	✓	✓	✓	✓	150
Osprey	✓	✓	✓	✓	500
Saunders's Tern	✓	✓	✓	✓	2,000
White-cheeked Tern	✓	✓	✓	✓	29,000
Bridled Tern	✓			✓	110,000
Greater Crested Tern	✓			✓	5,500
Lesser Crested Tern	✓			✓	41,000
Red-billed Tropicbird	✓			✓	50
Western Reef-egret	✓			✓	600
Common Gull-billed Tern				✓	10
Sandwich Tern				✓	10
Socotra Cormorant				✓	35,000
TOTAL	**20**	**7**	**4**	**13**	**244,030**



A SOOTY FALCON ON UMM LAJJ ISLAND IN THE RED SEA. SAUDI ARABIA'S ISLANDS ARE THE BREEDING STRONGHOLDS FOR THIS GLOBALLY VULNERABLE BIRD.

of seabirds (mainly gulls and terns) congregate to form dense, temporary nesting colonies at traditional breeding sites, particularly on the Farasan Islands and numerous islands between al-Wajh and Yanbu'. The most common seabird recorded in the Red Sea is the Bridled Tern: in 1996, 60,000 pairs were estimated nesting on Red Sea islands belonging to Saudi Arabia, along with 7,500 nesting pairs of Brown Noddy, up to 4,000 pairs of Lesser Crested Tern and 2,000 pairs of Brown Booby birds, with most nesting on vegetated islands.[1]

The Red Sea islands contain some globally important breeding populations of seabirds. For example, the White-eyed Gull only occurs in the Red Sea and Gulf of Aden. Likewise, many of the world's Crab-plovers and most of its Sooty Gulls breed on islands in the southern Red Sea.[2]

Surprisingly, some of the islands in the Red Sea are also important nesting sites for some terrestrial birds. Thousands of African Collared-doves migrate annually from the mainland to nest colonially on thickets of Toothbrush Tree on the Umm al-Qamari Islands off al-Qunfudhah (Makkah Province). They fly to the mainland to eat seeds, which they later regurgitate as crop milk to their offspring on the island. Further, Saudi Arabia's Red Sea islands (along with islands in the Arabian Gulf) are the breeding strongholds of most of the world's population of Sooty Falcon, which is listed as vulnerable globally and endangered regionally. Likewise, Farasan Island hosts about 30 breeding pairs of Egyptian Vulture, which scavenge carcasses from around the nearby islands. Indeed Farasan Island now contains the largest population of Egyptian Vultures in the Kingdom.[3] As this globally endangered species continues to decline, this Red Sea island population becomes increasingly important.

The Red Sea islands are not just extremely important sites for breeding birds, they also provide invaluable habitat for numerous winter visitors. At least 23 species regularly spend at least part of the winter foraging along the islands and coasts of the Red Sea. Further, dozens of species rest and forage on islands in the Red Sea every year as they migrate between their breeding sites in Eurasia and their wintering sites in Africa.

The importance of the Red Sea islands to Saudi Arabia's breeding and migratory birds has been recognized by Birdlife International, which has designated four island groups as globally *Important Bird and Biodiversity Areas:* the Farasan Islands, Kutambil Island, al-Wajh Bank and Umm al-Qamari.

MOST OF THE WORLD'S SOOTY GULL POPULATION BREEDS AND FORAGES IN THE RICH WATERS OF THE RED SEA.

MOST OF THE WORLD'S CRAB-PLOVER BREED ON ISLANDS IN THE SOUTHERN RED SEA.

A WESTERN REEF-EGRET FORAGES FOR FISH OFF THE COAST OF JIDDAH.

RED SEA COASTLINE

As we travel east from the Red Sea islands we soon encounter the picturesque western coast of Saudi Arabia. This tranquil coastline consists mostly of low-lying terrain with a sandy substrate often interspersed with large expanses of flat sabkhah. Some small sea cliffs are found along the Gulf of Aqaba.

The key sites for birds along the Red Sea coastline are, without doubt, patches of mangrove forest, which are a critical habitat for birds globally. Two mangrove species occur in Saudi Arabia, with the Gray Mangrove far more common than Loop-root Mangrove, which is confined to Farasan Islands.[4]

Why are mangroves so important to birds? Well, mangroves are truly remarkable trees because they grow in saltwater – primarily in the intertidal zone of sheltered marine shorelines, estuaries and islands. It is quite unusual for a tree to thrive in salty water, particularly in the intertidal zone where the anaerobic muddy conditions inhibit gas exchange between the roots and the air. To overcome these challenges, Gray Mangrove trees produce thousands of spongy aerial roots (20–30 centimeters high and a centimeter thick) that stick out above the mud. These aerial roots help to anchor the tree in the unstable intertidal zone and allow for gas exchange with the air.[5] The intricate network of millions of exposed roots in a mangrove forest provides vital habitat for countless organisms including algae, barnacles, insects, juvenile crustaceans and fish, which in turn forms an invaluable prey base for numerous bird species.[6]

THE RED SEA COASTLINE PROVIDES FORAGING HABITAT FOR MANY SPECIES. HERE A FLOCK OF CRAB-PLOVERS TAKE FLIGHT WHILE LARGE NUMBERS OF GREATER FLAMINGOES FORAGE IN THE DISTANCE.

Indeed some birds depend entirely upon mangroves for feeding and/or breeding habitat. For example, the only place in Saudi Arabia to find the "Red Sea Reed-warbler" (a subspecies of Common Reed-warbler that some regard as a distinct species)[7] is in mangroves along the Red Sea. The same applies for the utterly resplendent Collared Kingfisher. Further, the only places where the enigmatic "Mangrove White-eye" (*Zosterops sp. indet.*) have been recorded are a few isolated mangrove patches on the Red Sea coast of Saudi Arabia.[8] Likewise, Pink-backed Pelicans build their nest

AROUND 400 PAIRS OF PINK-BACKED PELICAN NEST ALONG THE RED SEA OFF SAUDI ARABIA.

MANY GREATER FLAMINGO SPEND THE WINTER FORAGING IN THE SHALLOW WATERS OF THE RED SEA AND ARABIAN GULF.

KNOWN AS THE MANGROVE REED-WARBLER, THIS SUBSPECIES OF COMMON REED-WARBLER FORAGES IN MANGROVES ALONG THE RED SEA.

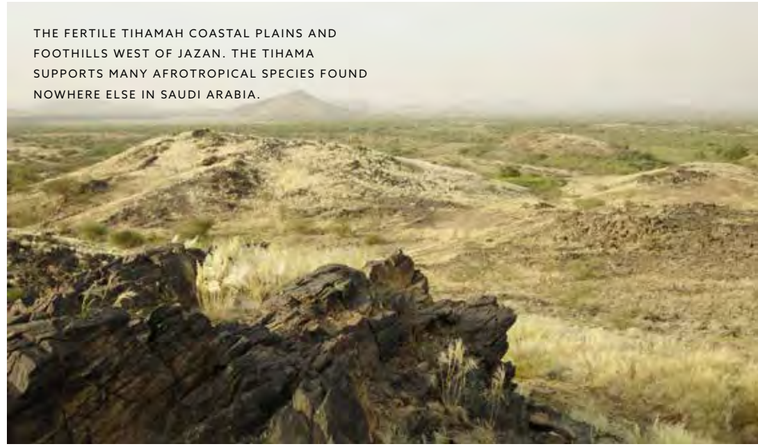
platforms in almost impregnable mangrove forests on Farasan Island. Ospreys and Sooty Falcons also occasionally use mangroves for nesting.[9] Red Sea mangroves are also important foraging habitat for several species, including Western Reef-egret, Green-backed Heron, Eurasian Spoonbill and Crab-plover, as well as many species of migratory and overwintering waders.

Unfortunately, large areas of mangrove forest have been cleared over the past few decades throughout the Kingdom. Now less than 51 square kilometers of mangrove habitat remains along the entire Red Sea coast, with the most extensive patches at al-Wajh, al-Lith and on the Farasan Islands.[10]

The importance of the Red Sea coast to Saudi Arabia's breeding and migratory birds cannot be overstated. Seven of the 39 *Important Bird and Biodiversity Areas* in Saudi Arabia currently recognized by Birdlife International incorporate Red Sea coastal habitat. Unfortunately, two of those (Qishran Bay and Jiddah south corniche and port) are listed as being in danger.

TIHAMAH COASTAL PLAIN

Heading east from the Red Sea, the next major habitat type we come across is the Tihamah. This captivating coastal plain stretches along the Arabian shore of the Red Sea up into the foothills of the grand 'Asir Mountain range. It varies in width from a few kilometers to around 100 kilometers at its broadest point near al-Lith. This narrow coastal strip – typically the hottest and most humid region in the Kingdom – is one of the richest areas for birds in Saudi Arabia for the simple reason that it is so close to Africa, thus allowing many Afrotropical species to thrive in this unique region.



THE FERTILE TIHAMAH COASTAL PLAINS AND FOOTHILLS WEST OF JAZAN. THE TIHAMA SUPPORTS MANY AFROTROPICAL SPECIES FOUND NOWHERE ELSE IN SAUDI ARABIA.

SEVERAL TYPICALLY 'AFRICAN' SPECIES OCCUR IN THE TIHAMAH, INCLUDING THE BEAUTIFUL ABYSSINIAN ROLLER.

ENDEMIC TO ARABIA, THE RESPLENDENT ARABIAN SUNBIRD OCCURS MAINLY IN THE FOOTHILLS OF THE 'ASIR MOUNTAINS.

The avifauna of the southern half of the Tihamah (south of 21°N) is particularly distinct, especially in the nearby foothills and increasingly so as one travels further south toward the Yemen border. Importantly, the area contains several endemic or near endemic species, including the Arabian Woodpecker, Arabian Green Bee-eater, Arabian Waxbill and Arabian Sunbird.[11] It is also a stronghold for the Arabian Golden Sparrow, with 80% of the global population occurring within the Tihamah of Saudi Arabia and Yemen (while the rest occurs in Djibouti).

The narrow Tihamah coastal strip is one of the richest areas for birds in Saudi Arabia.

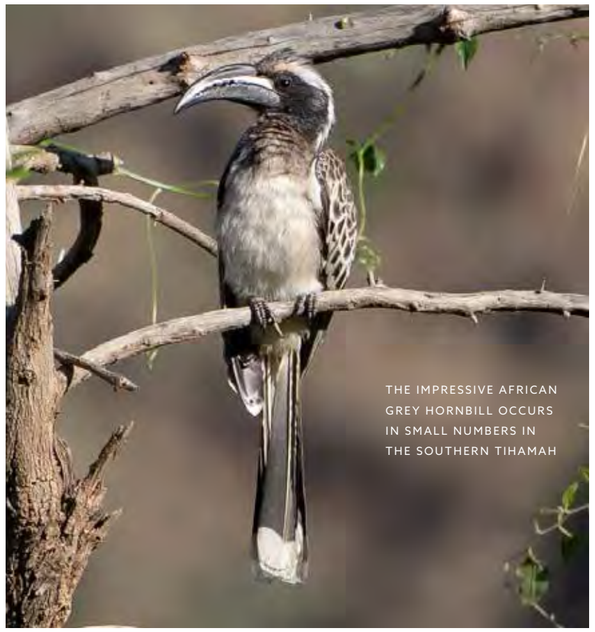
Other breeding residents that are found mainly in the Tihamah include such distinctly Afrotropical species as the African Collared-dove, White-browed Coucal, Abyssinian Roller, African Grey Hornbill, Black-crowned Tchagra, Horsfield's Bushlark, Zitting Cisticola, Rüppell's Weaver, and the African Palm-swift (which breeds only in Doum Palm trees within the Tihamah).[12] Wadis in the Tihamah tend to be richly vegetated and thus are especially attractive sites for birds, including rare species such as Helmeted Guineafowl, though in ever-diminishing numbers, and possibly the Arabian Bustard, though this species may now be extinct in the Kingdom.

Given its proximity to the African continent, it is not surprising that the Tihamah also receives several breeding migrants from across the Red

THE WHITE-BROWED COUCAL OCCURS ACROSS MUCH OF SOUTHERN AND EASTERN AFRICA WITH JUST A TOEHOLD POPULATION IN THE TIHAMAH OF SOUTHWESTERN ARABIA.

Sea, such as Common Buttonquail, Harlequin Quail, White-throated Bee-eater, Nubian Nightjar and the stately Abdim's Stork.[13]

Because many birds like to follow coastlines during migration, numerous passage migrants are recorded in the Tihamah as they travel between Eurasia and Africa. A notable example is the endangered Northern Bald Ibis, which



THE IMPRESSIVE AFRICAN GREY HORNBILL OCCURS IN SMALL NUMBERS IN THE SOUTHERN TIHAMAH

was recorded near Sabya in 2010 on migration between its breeding grounds in Syria and its wintering grounds in Ethiopia.[14]

As a result of the significant assemblage of birds in the Tihamah, Birdlife International has identified three *Important Bird and Biodiversity Areas* in this unique coastal plain (Wadi Rabigh Springs, al-Habrow al-Arabi and Wadi Jawah). Sadly, the latter two are classified as being in danger.

'ASIR MOUNTAINS

Travelling further east from the Tihamah coastal plain, we move quickly from the hottest region of Saudi Arabia to the coolest and wettest – the majestic southwest highlands. Soaring imperiously from the foothills above the Tihamah, the rugged 'Asir Mountains reach the Kingdom's highest peak (Jabal Sawda') at 2,983 meters before descending east to the central plateau at around 2,000 meters. Traditional agriculture using stone terracing is extensive on the slopes and plateaus of the 'Asir Mountains resulting in a landscape that is wonderfully rich in both natural and cultural heritage.

Stretching from Makkah to Yemen, these stunning mountains are a goldmine for birdwatchers. According to the Atlas of Arabian Breeding Birds, there are nine "hotspots" in Saudi Arabia where more than 50 species of bird have been recorded breeding – the southwest highlands host five of these nine hotspots. Indeed, at least 86 species may nest in some hotspots within the highlands[15] (*see* Figure 3, Chapter 1).

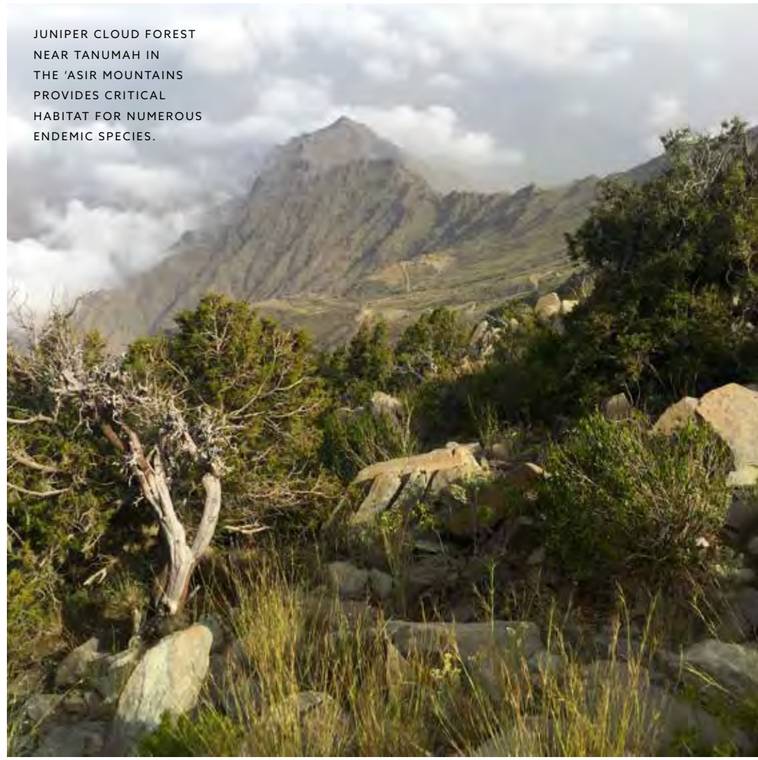
Why does such an extraordinary array of birds occur in the remote Southwest Highlands? First, the relatively cool and wet mountain climate supports the highest *density* of native vegetation in the Kingdom, and this dense vegetation is able to support a correspondingly high density of birds. Acacia trees are common and widespread, and lush cloud forests of Juniper covered in drooping epiphytic lichen occur in several areas, notably on Jabal Sawda'.[16] Second, the mountains contain a great *diversity* of habitat types, and each of these different habitat types supports a slightly different collection of birds. For instance, the mountains cover a great range of elevation, resulting in distinct vegetation changes as one descends the mountains.[17] The mountains are also very rugged, which creates innumerable microhabitats with distinct microclimates (different patterns of temperature, rainfall, wind, shade, etc.) within the broader altitudinal gradient. Each of these different microhabitats supports a distinct cluster of plants. In fact, an astonishing 2,000 plant species are estimated to

THIS NUBIAN NIGHTJAR MIGRATES ACROSS THE RED SEA TO BREED IN THE TIHAMAH PLAINS OF SAUDI ARABIA.

THE COOL, MOIST CLIMATE OF THE SOUTHWEST MOUNTAINS PROVIDES SUITABLE HABITAT FOR SEVERAL PRIMARILY AFRICAN SPECIES, INCLUDING THE ADORABLE LITTLE ROCK-THRUSH.

occur in the southwest highlands.[18] Accordingly the area has been formally listed as an international Center of Plant Diversity due to its globally important floristic richness and high endemism.[19] This extraordinary diversity supports a wide variety of invertebrates, amphibians, reptiles, and mammals, which in turn supports an equally impressive variety of birds.

Another reason for the exceptional diversity of birds in the southwest mountains is the proximity to the African continent. For several Afrotropical species, the cool, moist southwest highlands represent the only suitable breeding habitat in the Kingdom, including African Paradise-flycatcher, African Olive-pigeon, Dusky Turtle-dove, Little Rock-thrush, Brown Woodland-warbler, Montane Nightjar, Rufous-capped Lark, Abyssinian White-eye, and Bruce's Green-pigeon, among others. In addition, the nearness of Africa allows several Afrotropical breeding migrants to nest in the southwest highlands before returning to their African wintering grounds across the Red Sea, including the Grey-headed Kingfisher, Gambaga Flycatcher, Plain Nightjar, and the truly exquisite Violet-backed Starling.[20]



JUNIPER CLOUD FOREST NEAR TANUMAH IN THE 'ASIR MOUNTAINS PROVIDES CRITICAL HABITAT FOR NUMEROUS ENDEMIC SPECIES.

AN ABYSSINIAN WHITE-EYE AT TANUMAH IN THE 'ASIR MOUNTAINS. WHITE-EYES OCCUR IN THE SOUTHWEST HIGHLANDS AND, CURIOUSLY, IN PATCHES OF MATURE MANGROVE FOREST ALONG THE RED SEA COAST.

WHILE THE GREY-HEADED KINGFISHER OCCURS THROUGHOUT MUCH OF AFRICA, AROUND 1,500 PAIRS MIGRATE ANNUALLY TO NEST IN THE SOUTHWEST FOOTHILLS AND HIGHLANDS OF SAUDI ARABIA.

Most of Saudi Arabia's endemic land birds nest in the beautiful, jagged 'Asir Mountains, particularly in areas above 2,100 meters.

Significantly most of Saudi Arabia's endemic land birds also nest in these beautiful jagged mountains, particularly in areas above 2,100 meters.[21] Consequently the southwest has been identified as an internationally significant Endemic Bird Area: that is, this area is regarded as a globally critical region for the conservation of several restricted-range bird species.[22] Indeed one species, the Asir Magpie, occurs only in the 'Asir Mountains and nowhere else on earth.

The southwest mountains are also important because they support breeding populations of several threatened birds. For example, only around 25 pairs of regionally endangered Verreaux's Eagles still nest in Saudi Arabia, and most of these are found within the southwest highlands wherever suitable cliffs are available for nesting and Rock Hyrax (its mammal prey) are available for eating. More perilous still is the Bearded Vulture, which is vulnerable regionally and on the precipice of extinction nationally. If any still remain in the Kingdom, they are likely to nest in the southwest highlands.[23]

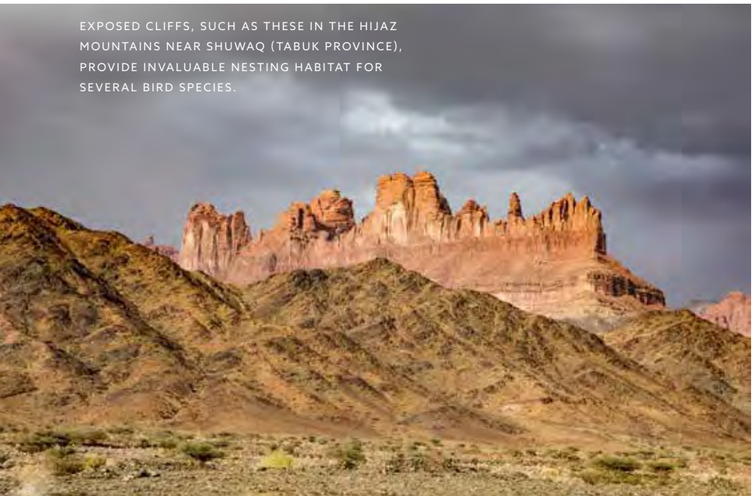
A GAMBAGA FLYCATCHER AT RAYDA RESERVE. THIS BIRD IS ONE OF SEVERAL AFROTROPICAL BREEDING MIGRANTS THAT NEST IN THE SOUTHWEST HIGHLANDS BEFORE RETURNING TO AFRICA FOR WINTER.

EVERY YEAR AROUND 40,000 PAIRS OF VIOLET-BACKED STARLINGS BREED IN THE HIGHLANDS OF SOUTHWESTERN SAUDI ARABIA BEFORE MIGRATING TO AFRICA FOR WINTER.

THE ENDEMIC YEMEN THRUSH FORAGES IN JUNIPER FOREST HIGH IN THE 'ASIR MOUNTAINS.

ENDEMIC TO SAUDI ARABIA, THE ASIR MAGPIE LIVES IN A FEW TINY PATCHES OF FOREST HIGH IN THE 'ASIR MOUNTAINS AND NOWHERE ELSE ON EARTH.

The 'Asir Mountains have a significant impact on many migratory species. Very few migratory birds spend the winter in the southwest highlands, presumably because of the cool winter climate. While most small to medium sized migratory birds avoid flying over the imposing southwest highlands, some of the large soaring raptors have no problem passing over this massive mountain range. For example, during October up to 4,000 migrating Eurasian Buzzards and 500 Steppe Eagles soar through a narrow pass in the Tayif escarpment every single day.[24]



EXPOSED CLIFFS, SUCH AS THESE IN THE HIJAZ MOUNTAINS NEAR SHUWAQ (TABUK PROVINCE), PROVIDE INVALUABLE NESTING HABITAT FOR SEVERAL BIRD SPECIES.

The value of the southwest highlands is recognized by Birdlife International, which has identified six *Important Bird and Biodiversity Areas* within the southwest highlands of Saudi Arabia. Unfortunately, one of those sites (Shallal ad-Dahna) is listed as in danger.

HIJAZ MOUNTAINS

Much like the 'Asir Mountains, the northern Hijaz Mountains (between Jordan and Makkah) contain significant bird assemblages, particularly in well-protected forested areas at higher altitudes. Several endemic and near-endemic species regularly occur in the Hijaz, including Arabian Woodpecker, Arabian Serin, Arabian Green Bee-eater, and Tristram's Starling. However, these northern mountains are not as rich in bird diversity as the southwest highlands. This is primarily because the Hijaz Mountains are not as high (with the tallest peaks only around 2,100 meters), less contiguous, less rugged, and drier than the 'Asir Mountains; thus they are more sparsely vegetated, and less floristically diverse, and therefore support fewer birds.[25] Nonetheless, Birdlife International has identified two *Important Bird and Biodiversity Areas* within the northern highlands, namely Hima al-Fiqrah and Jabal al-Lawz.

CENTRAL AND WESTERN SANDY-GRAVEL DESERTS

As we descend the eastern slopes of the western highlands, we encounter the vast sand and gravel deserts that typify much of central and western Saudi Arabia. Amazingly, the distribution of bird species found in central-western Arabia today is still affected by geological events that occurred millions of years ago. About 10–12 million years ago, the Arabian and African continents began to very slowly separate, eventually forming the Red Sea. As the continents gradually split apart, the ancient bedrock (some 0.5–3 billion years old) beneath Arabia was uplifted and eventually exposed through erosion.[26] This exposed bedrock, which is known as the Arabian Shield, covers around 445,000 square kilometers (or 20%) of Saudi Arabia, and is clearly visible on satellite images as the darker, more complex topography west of the Kingdom's great sand seas. As the exposed rock of the Arabian Shield weathered and eroded, it gradually affected the properties of the surrounding soil (such as pH, nutrient content, moisture-holding capacity, etc.). These soil characteristics directly influence the types of plants that can live above the Arabian Shield – and, in turn, these plants have a very large impact on the types of birds that can live in central and western Saudi Arabia.

LARGELY CONFINED TO THE ARABIAN PENINSULA, TRISTRAM'S STARLING IS COMMON IN THE 'ASIR AND HIJAZ MOUNTAINS.

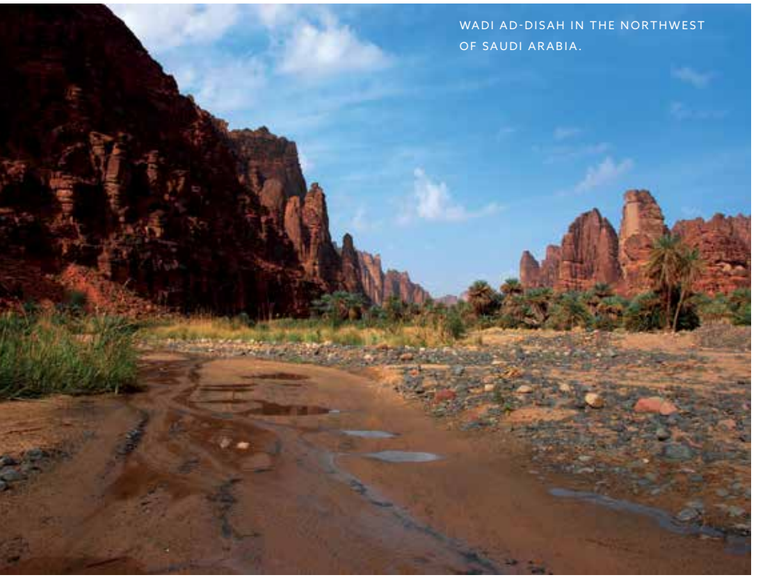
THE GLOBALLY ENDANGERED STEPPE EAGLE PASSES OVER THE 'ASIR MOUNTAINS DURING MIGRATION WITH 500 PER DAY FUNNELING THROUGH A GAP IN THE TAYIF ESCARPMENT DURING OCTOBER.

FAISAL PINNACLE AT QADMAT AS SAQṬAH, WEST OF RIYADH. DOZENS OF BIRD SPECIES ARE ADAPTED TO LIFE AMONGST THE VAST GRAVEL DESERTS OF SAUDI ARABIA.

ACACIA TREES LINE A WADI NEAR HAFIRAT NISAH, 70 KM SOUTHWEST OF RIYADH. SCATTERED ACACIA TREES PROVIDE IMPORTANT HABITAT FOR BIRDS THROUGHOUT MUCH OF THE CENTRAL REGION.

Amazingly, the distribution of bird species found in central-western Arabia today is still affected by geological events that occurred millions of years ago.

While the central region supports around 600 different plant species,[27] perhaps the most definitive plants of the central-western region are the Acacia trees. Usually growing to around eight meters tall, these stately, umbrella-shaped trees are present throughout most of the gravel deserts of western and central Saudi Arabia.[28] Acacia are the preferred nesting habitat of numerous bird species, not least the magnificent Lappet-face Vulture – one of the quintessential birds of the central region – which builds its massive nest on the flat top of a mature Acacia tree. Another bird that prefers to nest in Acacia is the Great Grey Shrike. This fascinating bird also uses the thorns of Acacia trees to impale its prey. In addition, the most common subspecies of Arabian Babbler (*Argya s. squamiceps*) also favors Acacia (though a second subspecies, *A. s. yemensis*, prefers habitats in the far southwest highlands).



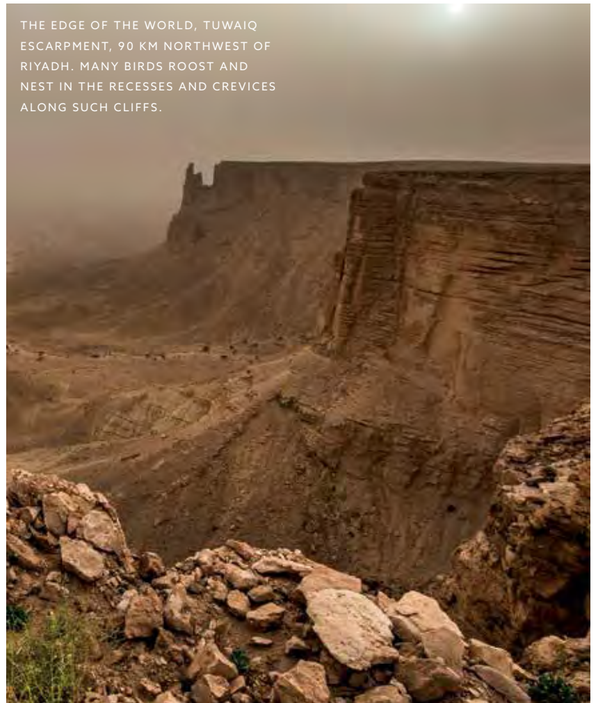
WADI AD-DISAH IN THE NORTHWEST OF SAUDI ARABIA.

The Arabian Shield further influences bird distribution due to its complex topography, which provides additional habitats for numerous birds that are rarely found elsewhere in the Kingdom. Thus, cliff-nesting species like Egyptian Vulture, Striolated Bunting and Pale Rock Martin can nest in the central-western region, as well as species that prefer to nest in boulder fields, such as Blackstart.

The ancient uplifting of the Arabian Shield also affects modern-day bird distribution because the tilted, raised bedrock has ultimately led to the formation of wadis, which act as drainage channels through the gravel deserts. These wadis are highly attractive to birds – not because they contain water (after all, most wadis are almost always bone dry at the surface), but because they contain a wide diversity and density of plants. For example, 126 plant species were recorded in Wadi al-Noman in Makkah province,[29] 157 plant species were recorded in Wadi al-Juhfah in the Najd,[30] and 196 plant species were recorded in Wadi ‘Ar’ar in the Northern Borders.[31] Such diverse plant communities support rich populations of invertebrates, reptiles, and mammals, which in turn provide a suitable food base for a wide variety of birds. Consequently, a number of bird species are most commonly found within wadis in the central-western region, including the Great Grey Shrike, Arabian Babbler and Striolated Bunting mentioned earlier, as well as Streaked Scrub-warbler, Sand Partridge, Trumpeter Finch, White-crowned Wheatear, and White-spectacled Bulbul. Another such species is the Arabian Green Bee-eater; these gorgeous near-endemic birds prefer habitat in and around wadis for two reasons: first, the large-grained sandy substrate allows the birds to excavate their long and narrow nest burrows without risk of the burrow collapsing; and second, the wadi vegetation supports sufficient numbers of the bee-eaters’ flying insect prey. Around 75,000 Arabian Green Bee-eater pairs nest annually in Saudi Arabia, with the majority occurring in wadis within this region.

AN UPCHER’S WARBLER FORAGING IN AN ACACIA TREE IN FULL BLOOM.

STRIOLATED BUNTINGS OFTEN NEST IN CLIFFS IN THE CENTRAL-WESTERN DESERTS.



THE EDGE OF THE WORLD, TUWAIQ ESCARPMENT, 90 KM NORTHWEST OF RIYADH. MANY BIRDS ROOST AND NEST IN THE RECESSES AND CREVICES ALONG SUCH CLIFFS.

LAPPET-FACED VULTURES NEST ON ACACIA TREES IN THE CENTRAL REGION. BELIEVE IT OR NOT, THIS BIRD IS STILL ONLY A NESTLING.

WHITE-SPECTACLED BULBULS CAN BE FOUND IN VIRTUALLY EVERY WADI IN THE CENTRAL AND WESTERN SANDY-GRAVEL DESERTS.

FENCED AREAS

Vegetation outside the wadis of the central-western region is typically rather meager. However, the rock and gravel deserts of Saudi Arabia were not always as sparse as they appear today. The density and diversity of plants within the kingdom's rangelands have been depleted through centuries of grazing by domestic livestock. On top of that, decades of off-road driving and excessive firewood collection have further reduced the amount of woody plants in the landscape. Sadly, what were once vast areas of natural steppe-like vegetation are now heavily desertified.

Thankfully, desert plants are amazing organisms. A single mature plant can produce tens of thousands of seeds that can remain dormant in the landscape for decades until favorable conditions stimulate germination.[32] Consequently, in most areas the ground is covered with a nearly invisible seed bank just waiting for generous rainfall. If a patch of land is protected, then these seeds are free to germinate allowing the biodiversity of the area to gradually recover.

We see the same pattern emerging time and time again across the kingdom: fenced areas contain significantly greater diversity and density of annuals, grasses, perennial forbs, shrubs and trees. They also contain fewer weeds and a greater proportion of palatable species.[33] The contrast between fenced and unfenced areas is often stark: for example, satellite images show an abrupt contrast between the relatively dense vegetation within the fenced King Fahd International Airport in Dammam and the barren area immediately beyond the fence.

As a direct result of the increased diversity and density of native plants, fenced areas usually contain many more birds than the surrounding desertified landscape. This is well demonstrated at Emam Saud Bin Mohammed Protected Area[34] (about 170 kilometers west of Tayif in central-western Saudi Arabia), where a 220-kilometer-long fence was erected in 1989 to protect 2,553 square kilometers, making it the second largest fenced wildlife enclosure in the world. Even though the area receives only 100 millimeters of rainfall per annum and summer temperatures can exceed 50˚C, this sizeable area is now very well vegetated with trees and dense grasses.[35] The natural vegetation has recovered. It is uplifting, inspiring, and moving.

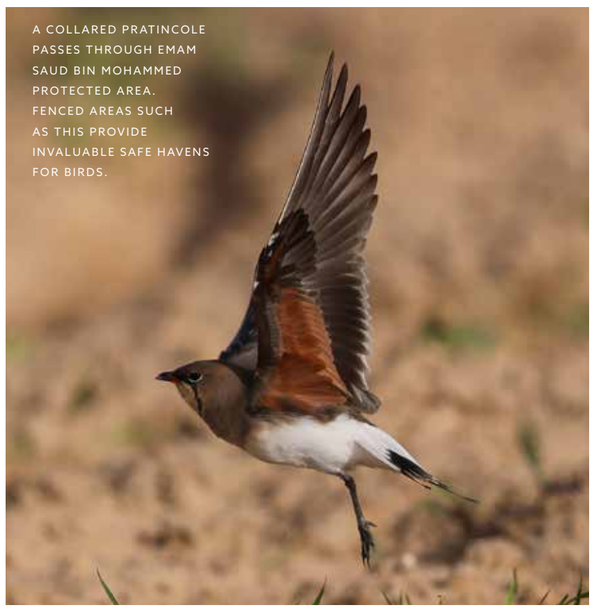
Consequently, the revitalized vegetation communities within Emam Saud Bin Mohammed Protected Area support over 160 bird species (39% of all of Saudi Arabia's regularly occurring birds), including dozens of breeding species. The area is an important safe haven for breeding Lappet-faced Vultures. The Asian Houbara has been reintroduced to the site since 1991 and has since been recorded breeding within the fenced area. Emam Saud Bin Mohammed Protected Area is also essential habitat for numerous migratory species with large numbers recorded on passage.[36]

A STREAKED SCRUB-WARBLER BRINGING FOOD TO ITS CHICKS IN A WADI IN THE WEST.

ARABIAN GREEN BEE-EATERS ARE COMMON IN ACACIA-FILLED WADIS OF THE CENTRAL AND WESTERN REGIONS.

WADI AT-TARJ NEAR BISHAH, A BEAUTIFUL PLACE TO WATCH BIRDS.

Similar spikes in bird density and diversity are likely to be found wherever well-managed fenced areas protect patches of native vegetation, including within some industrial compounds, military sites, and private reserves. These fenced areas provide an essential network of habitat patches across the kingdom. Just as islands provide vital stopovers for birds migrating across a vast ocean, protected patches of vegetation are effectively life-saving islands in the desert allowing large numbers of birds to migrate across Saudi Arabia.



A COLLARED PRATINCOLE PASSES THROUGH EMAM SAUD BIN MOHAMMED PROTECTED AREA. FENCED AREAS SUCH AS THIS PROVIDE INVALUABLE SAFE HAVENS FOR BIRDS.

Birdlife International has identified two large fenced areas within Saudi Arabia as globally Important Bird and Biodiversity Areas: Emam Saud Bin Mohammed Protected Area and the National Wildlife Research Center at Tayif, both located in the Central Region.

HARRATS AND JABALS

As we travel through the gravel deserts of Saudi Arabia we find extensive lava fields (known locally as *harrats*) and occasional massive rocky outcrops (known as *jabals*). At first glimpse, *harrats* seem like a muddled jumble of inhospitable rock, while *jabals* appear to be lifeless, inaccessible monoliths – but in fact *harrats* and *jabals* provide great habitat for birds, precisely because humans find them so inaccessible.

Harrats run along the western edge of the Kingdom from Harrat al-Harrah (King Salman Protected Area) on the border with Jordan to Harrat as-Sirat near the border with Yemen. Some are massive: Harrat Rahat is 310 kilometers long and covers 20,000 square kilometers between Makkah and Medina.[37] Most were formed through the intermingling lava flows that emerged from multiple eruptions, resulting in chaotic terrain that can be very difficult to walk or drive over. Indeed, some *harrats* (such as Harrat Khaybar) are so large, so remote and so rugged that they have not yet been fully explored.[38] The fact that they are so unreachable to humans has made them invaluable refuges for birds. Harrats that have been incised by an intact wadi system are particularly rich in avifauna.

The birds of the hauntingly beautiful Harrat al-Harrah (King Salman Protected Area) have been well surveyed. Even though the area is treeless, it nonetheless supports a wonderful collection of specialist breeding species, including: Asian Houbara, Cream-colored Courser, Thick-billed Lark, Bimaculated Lark, Temminck's Lark, Desert Tawny Owl, Little Owl, Pharaoh Eagle-owl, Golden Eagle, Streaked Scrub-warbler, Desert Wheatear, and many others.[39]

As is the case with *harrats*, some *jabals* are so large and rugged that they are virtually devoid of humans, and therefore safe havens for birds. For example, Jabal at-Tubayq is a large sandstone uplift in the northwest where Lappet-faced Vultures and Egyptian Vultures breed, and where Cinereous Vultures spend the winter. Likewise, Jabal Aja – an extensive outcrop of granitic mountains located southwest of Hayil city – is an important refuge for numerous breeding birds (including Desert Tawny Owl, Egyptian Vultures, Griffon Vultures, and Sand Partridge), winter visitors (Finsch's Wheatear), and passage migrants. Indeed, the site seems to lie at the center of the spring migration route for the threatened African population of Demoiselle Crane. Similarly, Hawtat Bani Tamim is a massive isolated hill on the Tuwaiq Escarpment (about 200 kilometers south of Riyadh) that contains a number of important breeding species, including Sand Partridge, Upcher's Warbler, and Ménétries's Warbler, not to mention Short-toed Snake-eagle, Pharaoh Eagle-owl and Fan-tailed Raven.

Harrats and jabals provide great habitat for birds, precisely because humans find them so inaccessible.

ELEPHANT ROCK NEAR AL-'ULA. ALTHOUGH JEBELS AND OUTCROPS SUCH AS THIS MAY APPEAR LIFELESS AND INHOSPITABLE THEY ACTUALLY PROVIDE IMPORTANT NESTING HABITAT FOR MANY BIRDS.

THE SAND PARTRIDGE IS MOST COMMON IN THE WADIS AND HARRATS OF THE WEST.

HARRAT KISHB, NEAR HAFIR KISHB. LAVA FIELDS OR "HARRATS" CREATE JUMBLED LANDSCAPES THAT ARE GENERALLY INACCESSIBLE TO PEOPLE AND CARS, MAKING THEM IDEAL REFUGES FOR BIRDS.

JEBELS AND BOULDERS PROVIDE INVALUABLE NESTING AND ROOSTING SITES FOR NUMEROUS BIRD SPECIES, INCLUDING LITTLE OWL.

PARTS OF THE NORTHERN SANDY-GRAVEL DESERTS CAN BURST INTO FLOWER AFTER SPRING RAIN.

Birdlife International has recognized the importance of these rugged landscapes by identifying four globally Important Bird and Biodiversity Areas: the savage beauty of Harrat al-Harrah (King Salman Protected Area), and the isolated jabals of Jabal at-Tubayq, Hawtat Bani Tamim, and Jabal Aja.

NORTHERN SANDY-GRAVEL DESERTS

Continuing our journey now to the sand and gravel deserts in the north of Saudi Arabia we encounter a slightly different assemblage of birds to those found in the central-western region. There are three principal reasons for these differences. The first is simple biogeography: as we travel further from Africa and nearer to Eurasia we naturally encounter increasingly fewer Afrotropical species and increasingly more Palearctic birds (that is, primarily Eurasian or North African birds). Indeed, virtually none of the Afrotropical species that dominate the southwest of the Kingdom can be found north of the Great Nafud Desert. Some Palearctic species specialize in the temperate deserts that occur between about 30˚N and 35˚N (which includes the northern deserts of Saudi Arabia). For example, Pin-tailed Sandgrouse, Thick-billed Lark, Temminck's Lark and Lesser Short-toed Lark all breed primarily within this narrow band of latitude across northern Africa, Syria, Iraq and Afghanistan, as well as the northern margin of Saudi Arabia.

Second, the Acacia trees that are so characteristic of the central-western region are generally absent in the northern plains, in part because Acacia seedlings are unable to tolerate the frequent winter frosts in the north. Thus, species that prefer to nest in Acacia (including Arabian Babbler, Great Grey Shrike, Lappet-faced Vulture and Brown-necked Raven) are less common in the north than in the center of the Kingdom.[40]

Third, there are few major wadi systems in the north, which means that wadi specialists – such as the endemic Arabian Green Bee-eater – are rarely recorded nesting in the northern region.[41]

The differences between the bird communities found in the central-western and northern regions become more apparent during the winter. The relatively cool climate of northern Saudi Arabia during the winter appears to be the

TEMMINCK'S LARK CAN BE FOUND THROUGHOUT THE GRAVEL DESERTS OF THE NORTH.

southern limit for several migratory species that spend the summer breeding in Eurasia. For example, Cinereous Vultures that breed in Mongolia usually spend the winter in the northern deserts.[42] Likewise, when conditions are suitable, up to 1,000 Pin-tailed Sandgrouse and dozens of Black-bellied Sandgrouse have been recorded wintering in the north.[43] Other Eurasian migrants that are more likely to spend the winter in the northern region include Hen Harrier, Bimaculated Lark, Lesser Short-toed Lark and (in some years) internationally significant numbers of Eurasian Dotterels. Importantly, some of the few remaining critically endangered Sociable Lapwings may also overwinter in the northern sand-gravel deserts if conditions are suitable.[44]

Unfortunately, the vegetation within the northern region has been severely depleted through overgrazing, off-road driving, firewood collection and other key threatening processes. Consequently, the only Important Bird and Biodiversity Area in the northern sand and gravel deserts identified by Birdlife International is the rugged, remote Harrat al-Harrah (King Salman Protected Area).

THE LESSER SHORT-TOED LARK CAN BE COMMON IN THE NORTHERN PLAINS IN WINTER WHERE ITS SAND-COLORED PLUMAGE PROVIDES EXCELLENT CAMOUFLAGE.

THE NORTHERN DESERTS OF SAUDI ARABIA MAY BE THE WORLD'S MOST IMPORTANT WINTERING AREA FOR THE GLOBALLY THREATENED EASTERN IMPERIAL EAGLE.

SAND SEAS

Travelling further east from the rock and gravel deserts of the central-western region we enter the truly astonishing sand seas that characterize much of Saudi Arabia – the Great Nafud in the north, the Rub' al-Khali in the south, and the Dahna Desert that connects them. These are some of the most dramatic and inhospitable landscapes on earth. But do not fall into the trap of assuming that birds are unable to survive here... birds are extraordinary creatures. The desert is not deserted. The Empty Quarter (Rub' al-Khali) is not empty.

Not surprisingly there are fewer bird species (and fewer individual birds) in the sand seas than anywhere else in Saudi Arabia – after all, these birds are enduring some of the most extreme conditions on earth. In summer in the Rub' al-Khali, temperatures regularly exceed 50°C in the shade. In direct sunlight, the temperature of the sand can surpass 80°C. Average annual rainfall is typically below 50 millimeter, and less than 25 millimeter in the central Rub' al-Khali. Some areas may not receive any rain at all for decades.[45] In some places, the sand dunes are over 250 meters tall. It is no wonder then that plant density and diversity are both extremely low. Despite covering around 500,000 square kilometers – an area as large as Spain – only 37 plant species can be found throughout the entire Rub' al-Khali.[46] There are no trees, and the meager vegetation provides minimal food, shade or nesting material. Birds that live here are surely some of the most impressive animals on earth, and deserve our respect, admiration and protection.

A few truly remarkable species seem to defy all odds and manage to breed regularly (albeit in small numbers) in the brutal spring and summer

SUPREMELY ADAPTED TO DESERT ENVIRONMENTS, THE INCOMPARABLE GREATER HOOPOE-LARK IS ABLE TO BREED IN THE HYPERARID CLIMATE OF THE RUB' AL-KHALI.

of these virtually waterless landscapes, including Long-legged Buzzard, Pharaoh Eagle-owl, Brown-necked Raven and the Greater Hoopoe-lark. The charismatic Cream-colored Courser occurs in relatively high densities within the Great Nafud and presumably nests there, laying its dust-colored eggs directly on the baking earth.

A few other species nest less often within the sand seas. For example, several nomadic lark species, including Arabian Lark and Bar-tailed Lark, wander through the deserts, occasionally building a nest. Lichtenstein's, Spotted, Crowned and Chestnut-bellied Sandgrouse all nest around the desert margins. The Little Owl is widespread throughout the sand deserts but can only nest where suitable crevices are found. Likewise, the Golden Eagle is restricted to breeding in rocky outcrops on the periphery of the Great Nafud. Historically, the Asian Houbara was a widespread breeding species within the sand seas, but decades

IMMENSE SAND SEAS NEAR SHAYBAH IN THE RUB' AL-KHALI DESERT. BIRDS CAN BE FOUND EVEN HERE.

of excessive hunting has caused this iconic bird to abandon the area.[47]

Not surprisingly, no migratory species fly to Saudi Arabia specifically to spend the winter within these scarcely vegetated habitats. However, many passage migrants fly over these vast deserts twice a year. Most fly at night and rest during the day in the sparse shrubs, which provide life-saving refuge from the blistering heat. Because there are so few people in the Rub' al-Khali, we have very few records of just how many birds migrate across this astonishing landscape.

Although there are no formally designated Important Bird and Biodiversity Areas within Saudi Arabia's sand seas, these immense stretches of sandy desert are regarded as one of the world's last true wildernesses, and accordingly the Saudi Wildlife Authority has proposed that a large portion of the Rub' al-Khali Desert should be designated as a Biodiversity Protection Area.

ARABIAN GULF COASTAL LOWLANDS

As we travel further east, we come to the low-lying coastal plains that fringe the Arabian Gulf and al-Hasa oasis. The avifauna of the Arabian Gulf coastal lowlands is quite unlike anywhere else in Saudi Arabia. There are two main reasons for this. First, the Gulf Coast's coastal sandy plains have been continuously populated for centuries or in some places millennia.[48] This long human presence coupled with recent rapid development has resulted in much of the landscape being largely transformed into a mosaic of cultivated, irrigated,

THE INDIAN SILVERBILL POPULATION IS INCREASING IN THE ARABIAN GULF LOWLANDS.

THE WHITE-EARED BULBUL IS ONE OF THE MOST COMMON BIRDS OF THE ARABIAN GULF COASTAL LOWLANDS AND SETTLED AREAS.

THE COMMON KINGFISHER IS A REGULAR WINTER VISITOR TO THE EAST COAST LOWLANDS, PARTICULARLY NEAR WETLANDS.

and urbanized habitats with very few areas of wilderness left. As a result, many of the typical birds of the coastal lowlands are commensal species that live in close association with humans.

Second, the relative nearness of the Indian subcontinent has allowed nearby Indo-Malay species to self-colonize the modified habitat, particularly over the last century as the rate of habitat modification has increased. For example, one of the most common birds in the eastern lowlands is the garrulous White-eared Bulbul. This lively bird is common around northwest India, southern Iran and Iraq. These days it also occurs in good numbers throughout cities, towns, parks and gardens in the eastern lowlands, though it seems to have been largely absent less than a century ago. The Indian Silverbill appears to have undergone a similar range expansion in recent decades.[49] In addition, several stunning Indo-Malay species occasionally visit the east coast lowlands during the non-breeding season, such as the Indian Roller, Common Kingfisher, and Purple Heron, enchanting local birdwatchers, photographers and poets alike.

The sand seas comprise some of the most dramatic and inhospitable landscapes on earth. But the desert is not deserted. The Empty Quarter is not empty.

AN ISABELLINE WHEATEAR RESTS IN THE RUB' AL-KHALI DESERT WHILE MIGRATING ACROSS SAUDI ARABIA.

A GLOBALLY VULNERABLE GREATER-SPOTTED EAGLE PERCHED IN TREES IN DHAHRAN.

The cultivated and irrigated landscapes along the coastal fringe also provide suitable wintering habitat for many primarily Eurasian species, such as Common Starling, Corn Bunting, Song Thrush, European Robin, Spanish Sparrow, Dark-throated Thrush, and Citrine Wagtail. Additionally many passage migrants are recorded in the Arabian Gulf coastal lowlands and the adjacent coastline as they travel between their Eurasian breeding grounds and their wintering sites in Africa, the Indian subcontinent or southern Arabia.

THE CLAMOROUS REED-WARBLER CAN BE FOUND IN MANY WETLANDS ALONG THE ARABIAN GULF COASTLINE.

Despite being largely modified, the Arabian Gulf coastal lowlands are still utilized by some threatened species. For example, globally vulnerable Greater Spotted Eagle can be found there in winter. Significant numbers of the globally endangered Basra Reed-warbler also occur in the eastern lowlands as they pass between their breeding grounds near the head of the Tigris and Euphrates rivers and their wintering grounds in eastern Africa. Unfortunately the globally endangered Egyptian Vulture – which was fairly common in the eastern lowlands 50 years ago – is now rarely seen and probably no longer breeds there. Worse still, the Lanner Falcon, which is critically endangered within Arabia, formerly bred along this coastal fringe but sadly it went extinct in the Eastern Province in the 1980s and now breeds only in the southwest.[50]

ARABIAN GULF COASTLINE

Travelling further east, we find ourselves standing on the sandy shoreline of the Arabian Gulf. Once again, mangrove communities are critical habitat for birds along the Gulf Coast. Unfortunately, much of the coastline has been highly modified: reclamation projects have drastically altered more than 40% of intertidal areas,[51] and virtually all mangrove forests have been cleared in the last century. Now only four square kilometers of old-growth mangroves are left (at Tarut Bay and al-Khafji) along the entire eastern coastline of Saudi Arabia.[52] These tiny remnants of the mangrove forest are important foraging habitat for tens of thousands of migratory waders. The loss of mangroves along the Gulf shores has no doubt had a significant impact on countless bird communities. Fortunately, Saudi Aramco's attempts to restore mangrove communities by planting over 2.2 million individual mangrove seedlings in key sites along the coast have proven highly successful and these established trees now support iconic species such as Greater Flamingoes, Eurasian Spoonbills and Osprey among many others.

Despite the loss of mangroves along the Arabian Gulf Coast, the coastal environment still provides several very important foraging areas for birds, supported largely by the high marine productivity of the Gulf waters.[53] Protected coastal bay systems in the Arabian Gulf contain a mosaic of highly productive ecosystems, including mudflats, seagrass beds and coral reefs that provide food and habitat for a wide diversity of birds. For example, within only three years (from 1992–1995) a staggering 275 bird species were recorded within the Jubail Marine Wildlife Sanctuary alone,[54] an area of coastline protected by adjacent headlands (Ras al-Khair and Ras Abu 'Ali). This represents more than half of all bird species ever recorded in the Kingdom. This coastal embayment harbors considerable numbers of migratory and wintering waders and waterfowl, including internationally important populations of at least 22 species as well as five globally threatened species.[55]

The importance of the Arabian Gulf coastline to the world's avifauna is underlined by Birdlife International, which has designated three inshore coastal areas (Abu 'Ali, Tarut Bay, and Gulf of Salwa) as Important Bird and Biodiversity Areas due to their remarkable assemblages of breeding and migratory birds.

LESSER SANDPLOVERS FORAGE ALONG THE ARABIAN GULF COASTLINE.

AROUND 10,000 PAIRS OF WHITE-CHEEKED TERNS NEST ON OFFSHORE ISLANDS IN THE ARABIAN GULF.

KURAYN ISLAND IN THE ARABIAN GULF.

Around one-third of the global population of Socotra Cormorants breed on Saudi Arabian islands in the Gulf.

ARABIAN GULF ISLANDS

Our journey across Saudi Arabia reaches its easternmost point at the Kingdom's subtropical islands in the sparkling Arabian Gulf. In contrast to the Red Sea, there are relatively few islands in the western Arabian Gulf: in total, 23 inshore sandy islands and six low-lying offshore coral islands in the Gulf belong to Saudi Arabia.

POMARINE JAEGER FORAGE IN THE RED SEA AND ARABIAN GULF.

Unfortunately several of the inshore islands have been heavily modified, and many now contain introduced predators (cats, rats and mice) that typically have significant impacts on nesting seabirds. Fortunately, the six offshore islands are in relatively good shape, composed of beautiful wide sandy beaches surrounded by extensive shallow coral reef platforms. The larger islands support dense vegetation, which provides shade for nesting seabirds. However, at least four of the offshore islands suffer from large numbers of introduced House Mouse, which harass nesting birds and can kill the nestlings.[56]

These inshore and offshore islands provide very important habitat for both nesting and migratory birds. At least 13 species nest regularly on these islands in the Gulf, including three species that very rarely breed anywhere else in Saudi Arabia (*see* Table 1). Indeed, about 35,000 pairs of endemic Socotra Cormorant breed on inshore islands in the Gulf (particularly in the Gulf of Salwa), which equates to around one-third of the global population of this internationally vulnerable species.

Furthermore, vast numbers of seabirds breed each year on the six offshore islands, including over 10,000 pairs of White-cheeked Terns and 35,000 pairs of Bridled Terns. These offshore islands are the world's most important breeding sites for Lesser Crested Terns with more than 25,000 pairs nesting annually.[57] Further, the offshore islands are used as a regular stopover site by large numbers of passage migrants (especially passerines), particularly in spring.

In addition, at least 31 species regularly spend the winter foraging in the productive waters of the Arabian Gulf, including 10 species that very rarely occur anywhere else in the Kingdom. Thus the Arabian Gulf is a resource that attracts some quite remarkable birds to Saudi Arabia. For example, the globally endangered Great Knot breeds in eastern Siberia, with most individuals wintering around coastal Australia and Southeast Asia; but interestingly a small population chooses to spend the winter in the Arabian Gulf, a staggering 9,000 kilometers from its Russian breeding grounds.

Birdlife International has designated the six offshore coral islands and the Gulf of Salwa as Important Birds Area due to the large number of breeding and migratory seabirds and waders that utilize these very beautiful sites.

MANGROVE TREES AT TARUT BAY ON THE ARABIAN GULF COAST PROVIDE ESSENTIAL HABITAT FOR AROUND 200 RESIDENT AND MIGRATORY BIRD SPECIES.

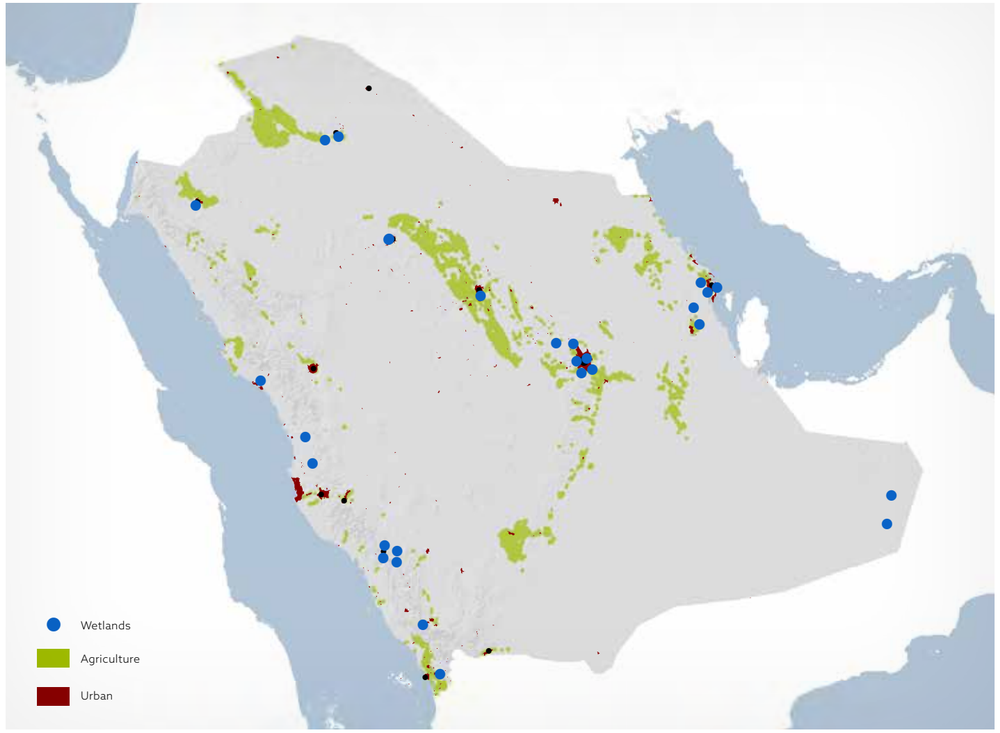


FIGURE 2: HEAVILY MODIFIED LANDSCAPES IN SAUDI ARABIA.

THE COMMON LITTLE BITTERN NOW BREEDS IN ARTIFICIAL WETLANDS THROUGHOUT THE KINGDOM.

BIRDS HAVE LIVED ALONGSIDE HUMANS FOR MILLENNIA, ESPECIALLY IN AREAS WITH GREEN SPACES, SUCH AS THESE ANCIENT DATE PALM PLANTATIONS AT DAWMAT AL-JANDAL.

Five of the ten most abundant breeding birds in Saudi Arabia occur primarily within our cities and towns.

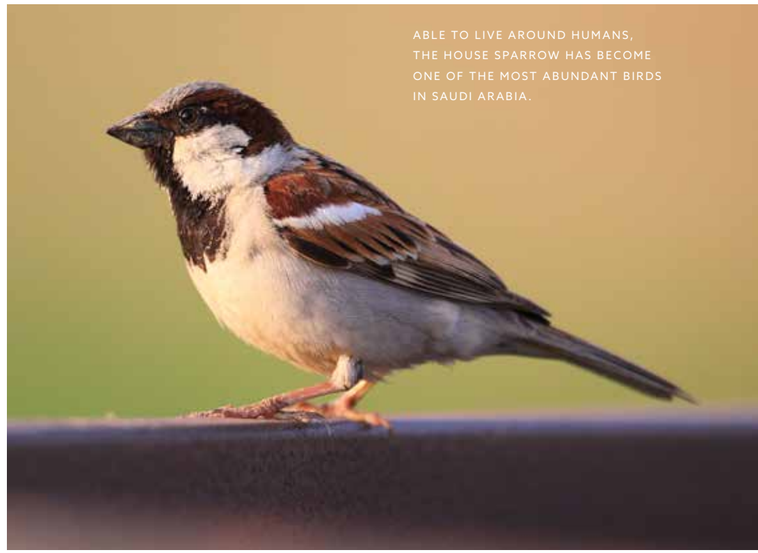
BIRDS IN MODIFIED LANDSCAPES

Superimposed over the various natural landscapes of Saudi Arabia are the habitats that we humans have created: our cities, our farms, and our constructed wetlands. As is the case throughout the world, these largely artificial habitats now exert an exceptionally important influence on the distribution and abundance of birds in Saudi Arabia.

CITIES AND TOWNS

Many people assume that built up areas are devoid of birds. However, cities and towns tend to contain large numbers of individual birds, albeit from a reduced range of species.[58] This is because only a small number of bird species are able to tolerate the constant disturbance of people and cars, find suitable nest sites on or around human structures, *and* exploit the exotic plants or animals typically found in urban habitats. Those few species that are able to live within human habitats experience little competition from other species, few natural predators, an abundance of artificial nesting sites, and almost ubiquitous food scraps.

Accordingly, five of the ten most abundant breeding birds in Saudi Arabia occur primarily within our cities and towns (*see* Table 2). These five "commensal species" (birds that live in close association with humans) comprise an estimated 8.5 million breeding pairs, with the vast majority nesting on human structures in settled areas. In other words, an astonishing 30% of all of Saudi Arabia's breeding pairs occur primarily within the 1% of land occupied by our built-up areas. This means that if people spend most of their time in cities and towns, they will seriously underestimate the diversity of birds found in Saudi Arabia. The other five most abundant breeding species all live chiefly within the sandy gravel deserts that cover vast areas of the Kingdom.



ABLE TO LIVE AROUND HUMANS, THE HOUSE SPARROW HAS BECOME ONE OF THE MOST ABUNDANT BIRDS IN SAUDI ARABIA.

EURASIAN COLLARED-DOVE, ONE OF ONLY A FEW SPECIES ABLE TO THRIVE IN CITIES AND TOWNS.

All of the exotic species found within Saudi Arabia occur almost exclusively within built-up areas (*see* Chapter 1, Table 2). Fortunately, only the Common Myna and House Crow have thus far reached significant numbers in multiple regions. Most exotic species are simply not able to penetrate intact ecosystems (because native species generally fill most available ecological niches) and usually lack the specific adaptations required to overcome the aridity and food scarcity of desert ecosystems.[59]

Although commensal and exotic species tend to dominate Saudi Arabia's built-up areas (as they do all over the world), there are nonetheless many fabulous resident and migratory species lurking within our urban gardens and parklands. Careful observers can regularly find interesting native birds breeding in urban areas across the Kingdom, including Pallid Swift, Pale Rock Martin, and Common Kestrel.[60]

TABLE 2: THE PRIMARY HABITAT OF THE 10 MOST COMMON BREEDING BIRD SPECIES IN SAUDI ARABIA.

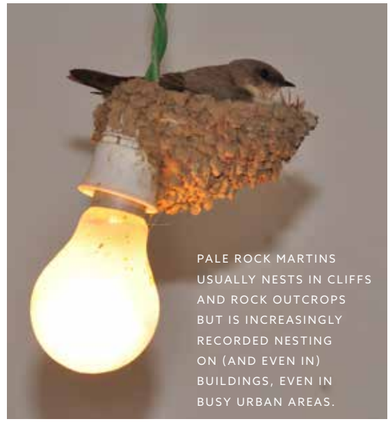
COMMON NAME	ESTIMATED BREEDING PAIRS	PRIMARY HABITAT
Desert Lark	4,500,000	Sand and gravel deserts
House Sparrow	4,000,000	Settled areas
Crested Lark	4,000,000	Sand and gravel deserts
Eurasian Collared-dove	1,500,000	Settled areas
White-spectacled Bulbul	1,500,000	Settled areas
Blackstart	900,000	Sand and gravel deserts
Laughing Dove	800,000	Settled areas
Rock Dove	750,000	Settled areas
Temminck's Lark	750,000	Sand and gravel deserts
Bar-tailed Lark	700,000	Sand and gravel deserts

ROSE-RINGED PARAKEET FEEDING ON EXOTIC TREES IN A GARDEN IN JIDDAH. INTRODUCED SPECIES SUCH AS THIS ARE MORE ABUNDANT IN HIGHLY MODIFIED HABITATS LIKE CITIES AND TOWNS

NILE VALLEY SUNBIRDS OCCASIONALLY NEST IN LEAFY SUBURBAN GARDENS.

Each region tends to have its own local species nesting in its urban gardens. For example, in built-up areas in the southwest birdwatchers can find such wonderful specimens as Tristram's Starling, Nile Valley Sunbird, Arabian Green Bee-eater, Black Kite, and even the endangered Asir Magpie. Likewise, one of the simplest places to see the gorgeous Rüppell's Weaver, for example, is in well-vegetated gardens in Jiddah where males industriously and repeatedly build (and then tear down) their numerous bell-shaped nests in an attempt to attract mates. Indeed, an astonishing 87 different bird species have been recorded in a single residential garden in Jiddah over the last 12 years by Duha Alhashimi, an avid birdwatcher and photographer.[61]

Like islands of greenery amongst a colossal sea of sand and gravel, shrubby parks and gardens in urban areas can provide important resting and foraging habitat for numerous migrating species, particularly when those gardens contain at least some native vegetation. In Dhahran, for example, it is not uncommon to find migratory species in residential gardens, including Blackcaps, Barred Warblers, Spotted Flycatchers, Common Hoopoe, Rufous-tailed Scrub-robin, and Western Yellow Wagtails, among many others. Indeed, more than 265 bird species have been recorded in Saudi Aramco's headquarters in Dhahran alone.[62]



PALE ROCK MARTINS USUALLY NESTS IN CLIFFS AND ROCK OUTCROPS BUT IS INCREASINGLY RECORDED NESTING ON (AND EVEN IN) BUILDINGS, EVEN IN BUSY URBAN AREAS.

AT LEAST 265 SPECIES OF BIRD HAVE BEEN RECORDED IN SAUDI ARAMCO'S HEADQUARTERS AT DHAHRAN, INCLUDING EURASIAN BITTERN.

One of the best ways to see birds in urban environments is to look up. That is, many aerial insectivores regularly forage above cities and towns, particularly during migration. For example, twice a year most Saudi Arabian cities briefly host countless European Bee-eaters as they migrate between Europe and Africa; these gloriously-colored birds rest on large urban trees or power lines in between dynamic aerial foraging bouts. Likewise, a seemingly continuous stream of migrating Common Swifts, Collared Sand Martins, Barn Swallows, and Northern House Martins regularly forage on the aerial insects that hover above built up areas.

Even Peregrine Falcons are occasionally seen during winter months soaring past high-rise buildings in Dhahran in pursuit of urban doves and pigeons. After suffering near global extinction in the 1970s due to worldwide use of DDT, this extraordinary species has recovered sufficiently to now breed on tall buildings in Europe and North America[63] and may one day breed in the cities and towns of Saudi Arabia.[64]

In short, while our built up areas can sometimes be teeming with a handful of commensal species, there is a special resident or migratory bird to be found in almost every park or garden, like a precious jewel amongst rocks. Indeed, the best place to see no less than 43 (or 11%) of the 401 species regularly recorded in Saudi Arabia is within our built-up areas. No doubt, this number will increase if we grow more native plants within our urban environments.

THE BLACK KITE IS COMMON IN CITIES AND TOWNS IN THE SOUTHWEST.

MIGRATING EUROPEAN BEE-EATERS REGULARLY PASS OVER CITIES AND TOWNS, PAUSING TO ROOST IN LARGE SUBURBAN TREES.

A RUFOUS-TAILED SCRUB EXPLORES A SUBURBAN GARDEN IN JIDDAH.

EURASIAN SCOPS-OWLS CAN OCCUR IN SUBURBAN GARDENS ON MIGRATION, BUT THEIR SUPERB CAMOUFLAGE AND CRYPTIC. NOCTURNAL BEHAVIOR ENSURES THEY ARE RARELY NOTICED.

Agricultural land can support large numbers of individual birds from a narrow range of species.

AGRICULTURAL LANDSCAPES

The rapid expansion of agriculture in Saudi Arabia in recent decades has had a very significant impact on the distribution and abundance of the Kingdom's birds. Large-scale intensive agriculture began in Saudi Arabia in the 1950s and increased rapidly in the 1970s and 1980s with the introduction of central pivot irrigation systems. Using satellite imagery and GIS analysis, it is apparent that approximately 211,000 square kilometers of flat sandy desert habitat has now been converted to croplands, particularly fodder (Alfalfa and Rhodes Grass), cereal (wheat, maize and barley) and vegetables (potato and onion).[65] In other words, vast sandy plains that once contained scores of native plant species now contain monocultures of exotic crops. These monocultures can support only a relatively limited range of invertebrates, which in turn can support only a limited range of birds. For the vast majority of birds in Saudi Arabia, these new pivot fields are simply unusable: most birds are unable to forage in them, nest in them, or rest in them. Thus the spread of agriculture has effectively eliminated most resident desert birds from around 10% of the Kingdom's land area.

For those few species that can exploit croplands, these high-density crops represent an enormous source of energy. In this way, agricultural lands are rather like cities: they can support large numbers of individual birds from a narrow range of species. Indeed sometimes thousands of birds from a single species can descend upon a

A DESERT LARK FINDS SOME RESPITE FROM THE HEAT AT AN IRRIGATED FIELD.

farm. For example, an estimated 16,000 breeding pairs of Crested Lark were recorded on a single 2,200-hectare pivot irrigated field near al-Kharj,[66] which is obviously well above the normal density of birds in the central deserts of Saudi Arabia. Desert Lark and Greater Short-toed Lark are also commonly recorded feeding on wheat and stubble in high numbers.[67]

Agriculture has not only affected the abundance of birds in the Kingdom, it has also affected the distribution of many species. For example, the spread of wheat farming has allowed Namaqua Dove and Black Scrub-robin to significantly expand from their relatively small native breeding ranges in the west to now cover much of the Kingdom.[68]

Further, the emergence of intensive irrigated croplands has allowed several species to self-colonize Saudi Arabia. For example, large-scale fruit farming since the 1980s has introduced an entirely new habitat to northern and central Saudi Arabia. These orchards have been particularly beneficial to the spread of Desert Finch. This gracefully ornamented finch with its lovely pink wings first began breeding in Saudi Arabia in the 1980s in

ONCE ONLY A WINTER VISITOR, THE CORN BUNTING NOW BREEDS IN AGRICULTURAL AREAS WITHIN THE EASTERN PROVINCE.

fruit orchards.[69] Now around 65,000 breeding pairs nest in farmlands across the northern and central regions. Similarly, Corn Bunting is generally a winter visitor to Saudi Arabia, but a small breeding population (perhaps 1,000 breeding

COMMON BARN-OWL CAN BE FOUND IN VILLAGES WITH SURROUNDING AGRICULTURAL LANDSCAPES.

THE SQUACCO HERON NOW BREEDS IN ARTIFICIAL WETLANDS IN RIYADH.

pairs) has recently emerged in agricultural areas within the Eastern Province and is likely to gradually expand as it continues to colonize suitable croplands.[70]

Large numbers of migratory species also utilize central pivot fields. This is because crops such as alfalfa are usually bristling with invertebrates, particularly caterpillars, which are high in saturated fat and thus an ideal energy source for migratory birds. For example, around 30 migrating Montagu's Harriers were recorded at one pivot farm in the central region one April. Flocks of over 1,000 Western Yellow Wagtails and 1,200 Red-throated Pipits have been recorded on a single field during migration,[71] while an astonishing 25,000 migrating Lesser Whitethroats were present on a fruit farm one spring morning.[72] Furthermore, some threatened species now rely heavily upon agricultural habitat for survival. For example, some critically endangered Sociable Lapwing spend the winter each year foraging in pivot irrigation fields near Haradh where groups of up to 10 have been found regularly over the last few years.[73]

COMMON HOOPOE OCCASIONALLY NEST IN SUBURBAN AREAS ACROSS MUCH OF SAUDI ARABIA; HERE A PAIR HAVE NESTED IN A HOUSE IN DHAHRAN.

THE SPREAD OF ARTIFICIAL WETLANDS IN RECENT DECADES HAS ENCOURAGED MANY MIGRATORY SPECIES TO BREED AND BECOME RESIDENT IN THE KINGDOM.

ARTIFICIAL WETLANDS

As is the case in most countries, some of the best bird sites in Saudi Arabia are artificial wetlands. This is because most treated effluent streams and wastewater ponds are exceptionally nutrient rich and therefore able to support dense reedbeds (often surrounded by bushes and trees) along with thriving communities of invertebrates, amphibians, reptiles, small mammals, and in some cases fish. As such, artificial wetlands provide a diverse prey base for a wide variety of birds. In addition, the dense reedbeds at artificial wetlands provide exquisite cover in which to nest or roost. Conversely, most ornamental ponds in cities and towns generally support very few wild birds, primarily because they tend to be surrounded by highly manicured, non-native vegetation and generally contain few reeds.

Given the extreme aridity that characterizes most of the Kingdom, it is not surprising that artificial wetlands are especially attractive to birds in Saudi Arabia. Indeed, Saudi Arabia is by far the largest country without a natural permanent freshwater river, and what was once the biggest

The emergence of artificial wetlands over the last 50 years has allowed several otherwise migratory species to establish breeding populations within the Kingdom.

LARGE NUMBERS OF RED-THROATED PIPIT CAN BE FOUND ON AGRICULTURAL FIELDS IN THE CENTER OF THE KINGDOM ON MIGRATION.

THE BLACK-WINGED STILT WAS PRIMARILY A PASSAGE MIGRANT THROUGH SAUDI ARABIA, BUT NOW AROUND 1,500 PAIRS REMAIN IN THE KINGDOM EVERY YEAR TO BREED IN ARTIFICIAL WETLANDS.

natural body of freshwater in the Kingdom (Layla Lakes in central Saudi Arabia) was drained in the late 1980s.[74] Although there are very few natural wetlands left in Saudi Arabia, the number of artificial wetlands has been steadily increasing since the first treated wastewater systems were established in the late 1960s. Artificial wetlands now exist near every large town or city, with particularly well-established wetlands at Abqaiq, Buraydah, Dhahran, Jubail, Makkah, Riyadh, Sakaka, and Tabuk.

The emergence of artificial wetlands over the last 50 years has allowed several otherwise migratory species to establish breeding populations within the Kingdom (*see* Table 3). For example, prior to the 1960s the Common Little Bittern usually passed over Saudi Arabia on migration between its wintering grounds in southern Africa and its breeding grounds in Central Asia. However, pairs soon began to find suitable nesting habitat around the Kingdom's new artificial wetlands. Rather than migrating to breed in Central Asia, some pairs became year-round residents of Saudi Arabia. This breeding population has continued to grow so that now around 400 pairs are estimated to live and breed in the Kingdom. Likewise, the Little Grebe (1,000 pairs), Black-winged Stilt (1,500 pairs), Common Moorhen (3,000 pairs) and Common Reed-warbler (3,900 pairs) were all primarily winter visitors or passage migrants through Saudi Arabia until the introduction of artificial wetlands enabled them to develop substantial populations of breeding residents. Indeed, perhaps as many as 24 former passage migrants now breed in Saudi Arabia because of the installation of artificial wetlands (*see* Table 3), including a tiny population of globally endangered Basra Reed-warblers. It is very likely that the breeding populations for many of these species will increase in number as they continue to colonize the Kingdom's constructed wetlands.

The high productivity of artificial wetlands provides a sufficiently nutrient rich and well-vegetated habitat to support dozens of breeding birds, not just wetland specialists. For example, at least 89 bird species have been recorded breeding within the 60-kilometer-long wastewater stream known as the Riyadh River or al-Hair watercourse.[75] That is, an astonishing 41% of all of Saudi Arabia's 219 breeding species have been recorded breeding in an artificial wetland that runs right through the Kingdom's capital city.

TABLE 3: MIGRATORY SPECIES THAT NOW BREED IN SAUDI ARABIA DUE TO THE PRESENCE OF ARTIFICIAL WETLANDS.

COMMON NAME	ESTIMATED BREEDING PAIRS	BEST PLACE TO SEE
Common Reed-warbler	3,900	al-Ha'ir / Riyadh River
Common Moorhen	3,000	al-Ha'ir / Riyadh River
Clamorous Reed-warbler	2,000	Eastern Province wetlands
Black-winged Stilt	1,500	Widespread wetlands
Little Grebe	1,000	al-Hasa lagoons
Common Little Bittern	400	al-Hasa lagoons
Common Coot	200	Eastern Province wetlands
Little Tern	200	Sabkhat al-Fasl lagoons
Mallard	200	al-Ha'ir / Riyadh River
Pied Avocet	200	Sabkhat al-Fasl lagoons
Great Reed-warbler	170	Eastern Province wetlands
Ferruginous Duck	160	al-Hasa lagoons
Purple Heron	80	Widespread wetlands
Western Water Rail	80	Eastern Province wetlands
Black-crowned Night Heron	50	al-Ha'ir / Riyadh River
Purple Swamphen	35	Sabkhat al-Fasl lagoons
Little Crake	30	Sabkhat al-Fasl lagoons
Squacco Heron	20	Eastern Province wetlands
Basra Reed-Warbler	10	al-Ha'ir / Riyadh River
Western Yellow Wagtail	10	Sabkhat al-Fasl lagoons
Spotted Crake	5	Sabkhat al-Fasl lagoons
Collared Pratincole	3	Sabkhat al-Fasl lagoons
Northern Shoveler	3	Eastern Province wetlands
Ruddy Shelduck	3	al-Hasa lagoons
White-breasted Kingfisher	3	al-Ha'ir / Riyadh River

Saudi Arabia's artificial wetlands also provide invaluable habitat for dozens of migratory species seeking food, water and shelter within the Kingdom's vast arid expanses. A particularly important wetland within Saudi Arabia is the al-Hasa lagoon system within the Arabian Gulf coastal lowlands where run-off from the enormous al-Hasa oasis supplemented by sewage water from Hofuf, Abqaiq and neighboring towns has created 7,500 hectares of wetlands. Large, dense reedbeds, sandy gravel plains, and well-vegetated sand dunes border many of the pools creating a rich environment for birds. Significant numbers of wintering and migrating waterbirds use the site annually, including numerous species of egrets, ducks, cranes, and waders numbering in their thousands.[76] Although surprisingly few extensive surveys have been conducted, it is likely that close to 200 bird species might be recorded at al-Hasa lagoons.

Large dams and reservoirs are also attractive sites for birds, including dams near al-Jawf, Abha and Malaki. The latter site, Malaki dam on the edge of the 'Asir foothills, is particularly rich. The roughly 10-square-kilometer dam is fed by four major wadis and adjoins a variety of marshy areas and freshwater pools, interspersed with a mixture of native and non-native trees. This is a birdwatcher's paradise: at least 287 species have been recorded here (70% of Saudi Arabia's regular birds), including one of the most diverse assemblage of breeding birds in Arabia. Large numbers of migrating White Stork, Common Crane, Glossy Ibis and Cattle Egret roost at Malaki dam on passage, while Black Stork, Eurasian Spoonbill and Black-tailed Godwit regularly spend the winter there.[77]

The impact of well-managed artificial wetlands on the Kingdom's birds and birdwatchers cannot be overstated. Constructed wetlands are the best place to see 92 (23%) of the 401 regular native birds of Saudi Arabia, including two threatened species (endangered Basra Reed-warbler and vulnerable Greater Spotted Eagle), and four near-threatened species (Ferruginous Duck, Black-tailed Godwit, Great Snipe, and Black-winged Pratincole). Birdlife International has identified seven of Saudi Arabia's artificial wetlands as being globally Important Bird and Biodiversity Areas, including five treated wastewater systems, one dam, and one reservoir/marshlands.

CONCLUSION

This tour of Saudi Arabia's natural landscapes underlines the surprising diversity of the Kingdom's ecosystems and the corresponding diversity of its birds. However, as we have seen in Chapter 1, these natural landscapes and the birds that depend upon them are under threat, as they are steadily replaced by increasingly modified human habitats. In order for birds and other biodiversity to persist, it is imperative that the remarkable natural landscapes of Saudi Arabia are protected and restored to their true glory.

A FLOCK OF CATTLE EGRETS PERCH ATOP A PIVOT IRRIGATOR. THE SPREAD OF AGRICULTURE IN RECENT DECADES HAS DRAMATICALLY CHANGED THE DISTRIBUTION AND ABUNDANCE OF BIRDS IN SAUDI ARABIA.

A BLACK REDSTART AT JABAL AJA IN NORTHERN HAYIL, ONE OF THE KINGDOM'S 39 DESIGNATED IMPORTANT BIRD AND BIODIVERSITY AREAS.

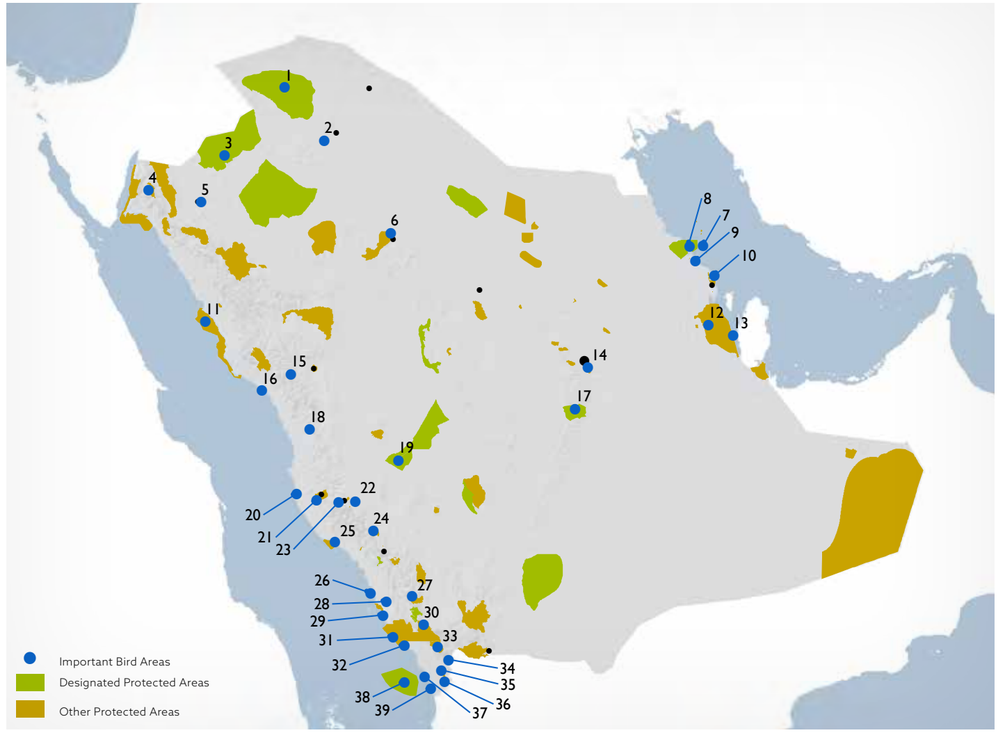


FIGURE 3: SAUDI ARABIA'S IMPORTANT BIRD AND BIODIVERSITY AREAS AND PROTECTED AREAS (DESIGNATED AND PROPOSED). AREAS SHADED GREEN ARE SAUDI WILDLIFE AUTHORITY DESIGNATED PROTECTED AREAS. AREAS SHADED ORANGE ARE EITHER PROPOSED PROTECTED AREAS OR PRIVATE PROTECTED AREAS.

BIRDLIFE INTERNATIONAL CRITERIA FOR DESIGNATION AS AN IMPORTANT BIRD AND BIODIVERSITY AREA

A1: Globally threatened species: the site is known or thought to regularly hold significant numbers of a globally threatened species.

A2: Restricted-range species: the site is known or thought to hold a significant component of a group of species whose breeding distributions define an Endemic Bird Area.

A3: Biome-restricted species: the site is known or thought to hold a significant component of the group of species whose distributions are largely or wholly confined to one biome.

A4: Congregations: the site is known or thought to hold congregations of ≥1% of the global population of one or more species on a regular or predictable basis.

B1: Regionally important congregations: the site is: (a) known or thought to hold ≥ 1% of a flyway or other distinct population of a waterbird species; (b) known or thought to hold ≥ 1% of a distinct population of a seabird species; (c) a bottleneck site where over 5,000 storks, or over 3,000 raptors or cranes regularly pass on spring or autumn migration.

B2: Species with an unfavorable conservation status in the Arabian Peninsula: the site is one of the five most important sites in the Kingdom for a species with an unfavorable conservation status in the Arabian Peninsula (threatened or declining throughout all or part of their range in the region) and for which the site-protection approach is thought to be appropriate.

B3: Species with a favorable conservation status but concentrated in the Arabian Peninsula: the site is one of the five most important sites in the Kingdom for a species with a favorable conservation status in the Arabian Peninsula but with its global range concentrated in the Middle East/Arabian Peninsula, and for which the site-protection approach is thought to be appropriate.

SOURCE: ADAPTED FROM BIRDLIFE INTERNATIONAL (2019A). FOR MORE INFORMATION SEE: HTTP://DATAZONE.BIRDLIFE.ORG/COUNTRY/SAUDI-ARABIA

SAUDI ARABIA'S IMPORTANT BIRD AND BIODIVERSITY AREAS

Since the late 1970s, BirdLife International and its partners have been identifying the places of greatest significance for the conservation of the world's birds. In Saudi Arabia, 39 Important Bird and Biodiversity Areas (IBAs) are internationally recognized (*see* the map below).

SITE NUMBER	IMPORTANT BIRD AND BIODIVERSITY AREA	BIRDLIFE INTERNATIONAL CRITERIA
8	Abu Ali	A4a, B1a, B3
14	Al-Hair	A1, B1a, B2
28	Al-Habrow al-Arabi	A3, B2, B3
12	Al-Hasa lagoons	A4c, B1a, B2
11	Al-Wajh Bank	A1, B2, B3
3	At-Tubayq	A1, B2, B3
2	Dawmat al-Jandl wetland	B1a
38	Farasan Islands	A1, A4a, B1a, B1b, B2, B3
7	Gulf coral islands	A1, A4a, A4c, B1a, B2, B3
13	Gulf of Salwa	A1, A4a, A4c, B1a, B2, B3
1	Harrat al-Harrah	A1, A3, B2, B3
17	Hawtat Bani Tamim	B3
15	Hima al-Fiqrah	A1, B2, B3
6	Jabal Aja and Northern Hayil	A1, A4a, B1a, B1c, B2, B3
4	Jabal al-Lawz	B2, B3
34	Jabal Fayfa	A1, A2, B2, B3
33	Jabal Qaha – Lajib gorge	B3
20	Jiddah south corniche and port	A4a, B1a, B2
37	Jazan Bay	A1, A4a, A4c, B1a, B2, B3
29	Khawr 'Amiq	B2
39	Khawr Wahlan	B3
5	King Faisal Airbase, Tabuk	B1a, B2
31	Kutambil island	A4a, B1a, B2
16	Madinat Yanbu al-Sinaiyah	A1, B1a, B2, B3
19	Mahazat as-Sayd	A1, B1a, B2, B3
21	Makkah wastewater stream	A4a, B1a, B2
35	Malaki dam	A1, A4a, B1a, B2, B3
22	National Wildlife Research Center and environs, Tayif	A1, A4a, B1a, B2, B3
25	Qishran Bay	B1a, B2, B3
30	Rayda escarpment	A1, A2, A3, B2, B3
9	Sabkhat al-Fasl lagoons	A4a, A4c, B1a
27	Shallal ad-Dahna	B2, B3
32	Shuqayq mangrove	A1, B2
23	Tayif escarpment	A1, A2, A3, B1c, B2, B3
10	Tarut Bay	A4a, A4c, B1a, B3
26	Umm al-Qamari	A4a, B1a, B3
36	Wadi Jawah	A1, B1c, B2, B3
18	Wadi Rabigh springs	B1c
24	Wadi Turabah and Jabal Ibrahim	A1, A2, A3, B2, B3

A FEMALE AFRICAN PARADISE-FLYCATCHER INCUBATES HER EGGS AT THE DELICATELY ORNAMENTED NEST.

CHAPTER 4

The Challenges of Breeding in Saudi Arabia

KEY POINTS

- Every year, 27 million pairs of birds from 219 species nest in Saudi Arabia.
- Each species employs its own behavioral and physiological strategies for overcoming the extreme heat, lack of water, lack of nest protection and high predation rates.
- Breeding birds seek shade wherever they can find it and exhibit reduced metabolic rates to minimize their food and water needs.
- Birds breed when food availability peaks: thus most land birds nest in spring and most seabirds nest in summer.
- Some birds choose not to breed during particularly difficult years.
- Birds use a range of fascinating strategies in order to attract a mate and repel rivals, including song, plumage, and resources.
- Given the extreme challenges of nesting in Saudi Arabia, any disturbance to the nest can be fatal. We must tread carefully.

A PHARAOH EAGLE-OWL INCUBATES HER THREE PRECIOUS EGGS AT A JABAL IN THE EASTERN PROVINCE.

THE BATTLE TO BREED IN A HARSH LAND

For a bird, there must be few places more challenging to breed than the deserts of Saudi Arabia. Throughout much of the Kingdom, air temperature soars during the day and plummets at night, rainfall is rare and unpredictable, food is scarce, and in many places meager vegetation provides little protection from weather or predators. Nonetheless, from the Juniper-covered mountains of the southwest to the vast stony plains of the northeast, and from the offshore islands of the Arabian Gulf to the immeasurable sand seas of the Rub' al-Khali desert, nowhere in Saudi Arabia is devoid of breeding birds. Indeed, 219 species have been recorded nesting in the Kingdom comprising an estimated 27 million breeding pairs per year.[1]

At least 175 breeding species live in Saudi Arabia year round, with some breeding in vast numbers, including 4 million pairs of House Sparrow, four million pairs of Crested Lark and 4.5 million pairs of Desert Lark. Others breed only very rarely within Saudi Arabia, such as White-breasted Kingfisher, Black-winged Kite, and Greater Painted-snipe, which may have less than 10 pairs between them.

From the Juniper-covered mountains of the southwest to the vast stony plains of the northeast, and from the offshore islands of the Arabian Gulf to the immeasurable sand seas of the Rub' al-Khali desert, nowhere in Saudi Arabia is devoid of breeding birds.

A BAR-TAILED LARK IN A SANDSTORM. DESPITE THE ARID, HOT AND WINDY CONDITIONS ACROSS MUCH OF SAUDI ARABIA, AT LEAST 219 SPECIES HAVE BEEN RECORDED BREEDING IN THE KINGDOM.

REPRODUCTIVE SUCCESS. A NEWLY FLEDGED CRESTED LARK CHICK TAKES ITS FIRST TENTATIVE STEPS INTO THE DESERT LANDSCAPE.

A MALE CRESTED LARK DISPLAYS TO IMPRESS A NEARBY FEMALE.

A WELL-CAMOUFLAGED NESTING DESERT LARK BLENDS INTO THE LANDSCAPE. THE ADULTS BUILD THEIR NEST IN THE MOST PROTECTED LOCATION THEY CAN FIND AND PLACE PEBBLES AROUND THE NEST FOR ADDITIONAL CAMOUFLAGE.

A further 32 species migrate every year to breed in Saudi Arabia; some arrive in small numbers, such as Abdim's Stork (40 pairs), Savi's Warbler (eight pairs) and Ruddy Shelduck (three pairs), while others arrive en masse, including over 40,000 pairs of Violet-backed Starlings, 50,000 pairs of Gambaga Flycatchers, and more than 100,000 pairs of Bridled Terns. As we demonstrate in this chapter, all of these birds employ a wide variety of strategies to overcome the extreme challenges of breeding in Saudi Arabia.

A DESERT LARK BRINGS FOOD TO ITS NEST. WELL ADAPTED TO DESERT ENVIRONMENTS, THIS IS THE MOST COMMON BREEDING BIRD IN SAUDI ARABIA WITH AN ESTIMATED 4.5 MILLION PAIRS BREEDING EACH YEAR.

MOST COLLARED PRATINCOLE ARE PASSAGE MIGRANTS THROUGH SAUDI ARABIA; HOWEVER A VERY SMALL NUMBER REMAIN IN THE KINGDOM TO BREED.

EACH YEAR, 46 SPECIES MIGRATE TO SAUDI ARABIA TO BREED, INCLUDING AROUND 50,000 PAIRS OF GAMBAGA FLYCATCHER.

A VERY YOUNG HOUSE SPARROW LEARNS HOW TO PERCH. NATIVE TO SAUDI ARABIA, AROUND 4 MILLION PAIRS BREED PER ANNUM.

WHEN DO BIRDS BREED IN SAUDI ARABIA?

Most birds attempt to nest during annual peak food availability. Thus in Saudi Arabia most insectivorous or herbivorous birds breed in spring and early summer (from March to July) when many invertebrates become more active and most plants produce new leaves, flowers, fruits and seeds. Overall, 74% of nesting activity in Saudi Arabia occurs in the five months from March to July (*see* Figure 1), peaking in May when up to 95% of all breeding species may be nesting. Nonetheless, since Saudi Arabia experiences highly irregular rainfall, the annual breeding schedule for most land birds is generally less well defined than in temperate climates. Some smaller species (for example, several larks) will simply skip breeding for a year if conditions are unsuitable.

THE REGAL BLACK-WINGED KITE IS ONE OF THE RAREST BREEDING BIRDS IN SAUDI ARABIA.

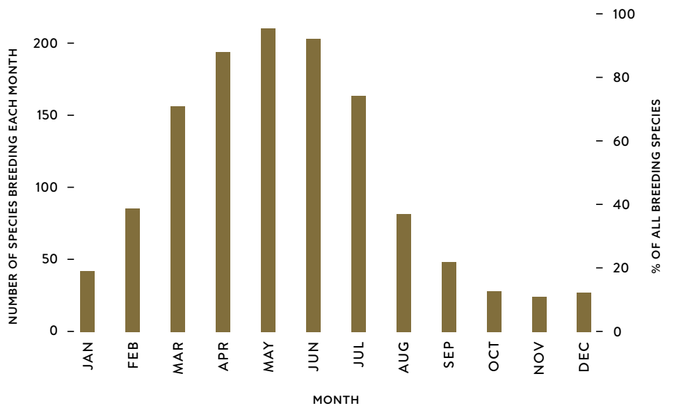


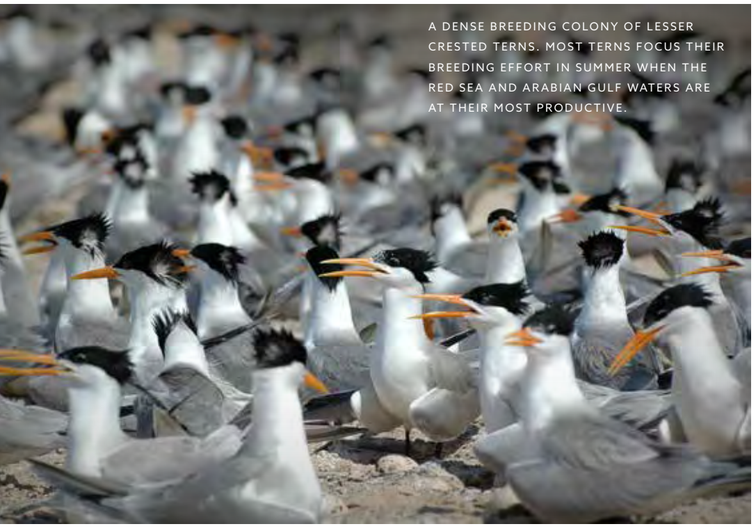
FIGURE 1: MONTHLY FREQUENCY OF BREEDING ACTIVITY AMONGST ALL 219 BREEDING SPECIES IN SAUDI ARABIA.

A STATELY BRIDLED TERN ON KARAN ISLAND. OVER 100,000 PAIRS MIGRATE EACH YEAR TO BREED ON THE KINGDOM'S ISLANDS MAKING IT THE MOST ABUNDANT BREEDING MIGRANT IN SAUDI ARABIA.

SMALL BIRDS LIKE
GRACEFUL PRINIA
CAN COMPLETE THEIR
NESTING CYCLE IN ONLY
23 DAYS.

LARGE BIRDS LIKE THE PHARAOH EAGLE-OWL TAKE SEVERAL MONTHS TO INCUBATE, GROW AND FLEDGE. THIS JUVENILE STILL HAS WEEKS TO GO.

For some birds food availability peaks not in spring but in summer. For example, Crab-plovers nest from May to August when their crab prey becomes most abundant. Many seabirds, including Red-billed Tropicbirds, gulls and most terns focus their breeding effort from June to September when the Arabian Gulf and Red Sea are most productive. Similarly, the Sooty Falcon breeds primarily from July to October when it can feed its young on the sudden increase in small birds migrating southwards from Eurasia (many of which are juveniles attempting to fly across Saudi Arabia for the first time having fledged only a few weeks before). Amazingly, these summer-breeding birds are nesting during the hottest time of the year in one of the hottest places on earth at the hottest time in history.



A DENSE BREEDING COLONY OF LESSER CRESTED TERNS. MOST TERNS FOCUS THEIR BREEDING EFFORT IN SUMMER WHEN THE RED SEA AND ARABIAN GULF WATERS ARE AT THEIR MOST PRODUCTIVE.

Conversely a small number of birds nest during the *coolest* time of year from October to March, including the African Palm-swift, Pink-backed Pelican, Goliath Heron, and Arabian Bustard (historically). The breeding biology and foraging ecology of these species is so poorly known that one can only speculate as to why they nest in winter.

Larger birds usually commence nesting earlier in the breeding season (*see* Figure 2). This is because the duration of a bird's incubation and nestling period generally increases with adult body mass. For instance, while the young of tiny birds like the Graceful Prinia may leave the nest only 23 days after the egg was laid, the nesting period for larger birds may last for six months or more. Therefore hefty birds like the Pharaoh Eagle-owl, eagles and vultures usually start nesting in winter (or in some cases Autumn) to allow sufficient time to fledge their chicks prior to the onset of the oppressive heat of late summer. However, these early-nesting species are certainly in the minority: while around 74% of nesting activity occurs in the five months from March to July, less than 16% occurs in the five months from October to February.

Some species have the capacity to nest all year round. For example, commensal species that have adapted to living alongside humans, including the Eurasian Collared-dove, Laughing Dove and the ever-present House Sparrow, can find sufficient food and shelter in our cities and towns to breed at any time of year. The familiar Rock Dove that has colonized most settlements around the world can nest in any month and produce up to five broods

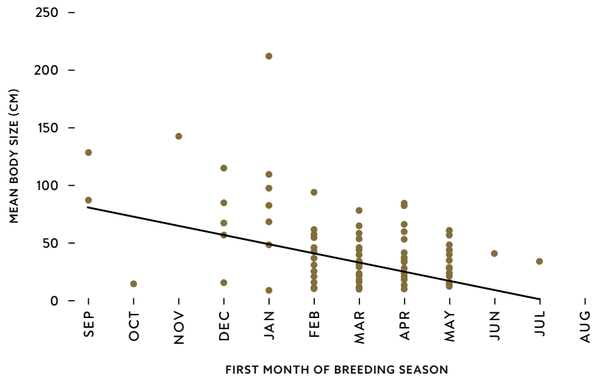


FIGURE 2: BIRD SIZE VERSUS MONTH OF FIRST BREEDING AMONGST ALL 219 BREEDING SPECIES IN SAUDI ARABIA. LARGER AND HEAVIER BIRDS COMMENCE BREEDING EARLIER IN THE SEASON.[2]

In Saudi Arabia, 74% of nesting activity occurs in the five months from March to July, peaking in May when up to 95% of resident species may be breeding.

A COMMON BARN-OWL HAS FOUND SOME PREY FOR ITS CHICKS. BIRDS TIME THEIR NESTING SEASON TO COINCIDE WITH PEAK FOOD AVAILABILITY.

per year. Nevertheless the breeding season for such commensal species still usually peaks in the spring months when conditions are most favorable for finding food.

OVERCOMING THE CHALLENGES OF BREEDING IN SAUDI ARABIA

Birds breeding in Saudi Arabia are certainly faced with a daunting task. For most birds a body temperature above 46–47°C is fatal, yet during the breeding season much of Saudi Arabia can exceed 50°C in the shade and more than 65°C in direct sunlight. The surface of the sand or rocks can exceed 80°C. Add to that, desiccating winds, almost no surface water, scarce food, and very little shade, and we can begin to appreciate how truly extraordinary it is that 219 species of birds manage to breed in some of the most challenging conditions on earth. The lack of food in the desert means that birds must spend extra time foraging, but that exposes them to the ever-present heat, sunlight and predators. In this section we use case studies to demonstrate how birds breeding in Saudi Arabia manage to walk this tightrope.

CASE STUDY 1: GREATER HOOPOE-LARKS, BALANCING FOOD AND SHADE

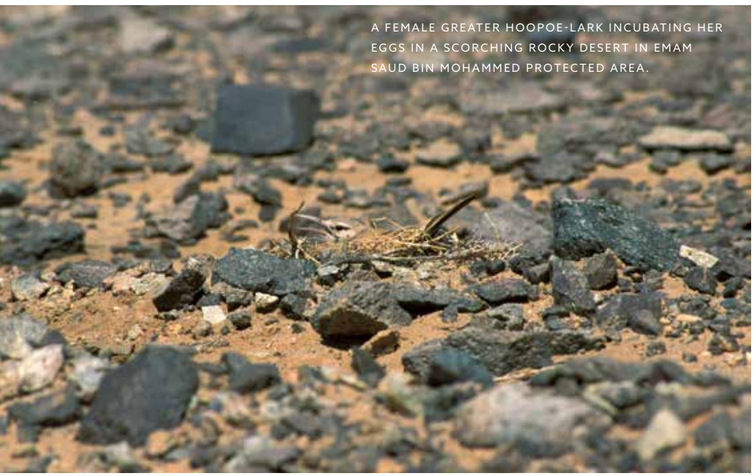
To understand how birds breed in such a harsh environment, we can find no better model than the Greater Hoopoe-lark, which has been studied at Emam Saud Bin Mohammed Protected Area. These plucky little birds feed mainly on arthropods, some plant matter and the occasional small

THE DELICATE NEST OF AN ABYSSINIAN WHITE-EYE HIGH IN THE 'ASIR MOUNTAINS.

A TEMMINCK'S LARK INCUBATES HER EGGS.

OVER SUMMER IN SAUDI ARABIA HEAT RADIATING FROM THE GROUND CAN EXCEED 70°C. GREATER HOOPOE-LARKS HAVE EXTRAORDINARY ADAPTATIONS THAT ALLOW THEM TO FORAGE AND NEST DIRECTLY ON THE BAKING GROUND.

reptile, which they glean from the ground with their elegantly curved bill. Such ground-foraging behavior exposes Hoopoe-larks to lethal temperatures. Consequently, during the breeding season (March through to September in some years) they have only a few hours in the early morning and late afternoon in which it is safe to find food for themselves and their chicks. Even then they typically forage beneath what little shade they can find. They spend much of their day sheltering in bushes, finding a spot half way up the bush that avoids direct sunlight from above and heat radiating from the baking ground below.



A FEMALE GREATER HOOPOE-LARK INCUBATING HER EGGS IN A SCORCHING ROCKY DESERT IN EMAM SAUD BIN MOHAMMED PROTECTED AREA.

Greater Hoopoe-larks also employ other more shrewd methods for keeping cool. For example, occasionally a Hoopoe-lark will lie flat on a dense, dark, mat-like plant (such as *Corchorus depressus*), which provides a humid and slightly cooler microclimate; any breeze then cools the bird's moist body for a few seconds of much-needed respite.[3] They will also sneak into the burrow of a Dhub where they spend hours below ground protected from the sun's rays and withering winds. This behavior reduces the bird's total evaporative water loss by over 80%,[4] demonstrating that shade is critical for Hoopoe-lark survival.

Greater Hoopoe-larks also have a suite of physiological adaptations that allow them to withstand intense heat and aridity. Desert species have subtle modifications in the outer layer of their skin, which significantly reduces evaporative water loss on hot days. In one study comparing 20 species from Saudi Arabia and around the world, the five species with the lowest rates of water loss were all larks from Saudi Arabia: Black-crowned Sparrow-lark, Crested Lark, Desert Lark, Arabian Lark, and of course the Greater Hoopoe-lark. Despite living in hyperarid deserts, the Hoopoe-lark loses about half as much water through the skin as similar birds living in temperate environments.[5] Interestingly, the permeability of its skin reduces even further as temperature steadily increases during the breeding season, which reduces water loss by an additional 25%.[6]

Avoiding the midday heat comes at a cost – it severely limits the amount of time available to find food, which is a significant problem in Saudi Arabia where prey is scarce and hard to find. Because of the chronic shortage of food, Greater Hoopoe-larks have a significantly reduced metabolic rate. Indeed, the metabolic rate of the Hoopoe-lark is more than 40% lower (and thus body temperature is 1.1°C lower) than similar larks from temperate areas. Furthermore, the metabolic rate of the Hoopoe-lark is flexible and adjusts to match its environment: when air temperature increases during spring and summer, the already low basal metabolic rate decreases even further. This in turn means that Hoopoe-larks need to eat less food than similar-sized larks from temperate environments: compared to their temperate counterparts, Hoopoe-larks and their offspring require 30% fewer calories to survive. Astonishingly, the digestive organs themselves decrease by about 25% as temperature increases, which further suppresses their need for food and water during periods of heat and hardship.[7]

Avoiding the midday heat comes at a cost – it severely limits the amount of time available to find food, which is a significant problem in Saudi Arabia where prey is scarce and hard to find.

While the reduced metabolic rate of Hoopoe-larks lowers their food requirements, it means they have less energy to devote to producing offspring. Therefore, Hoopoe-larks and many other desert birds lay smaller clutches (2–3 eggs) with significantly reduced growth rates compared to larks from temperate environments (4–5 eggs).[8]

Even with its reduced energy requirements, small clutch and slow growth rate, there are nonetheless many years when the Kingdom's deserts are simply too unproductive for Hoopoe-larks to reproduce. In the deserts of Saudi Arabia, several months – indeed several years – can pass without a drop of rain. During these prolonged droughts, the Kingdom's larks do not breed at all, which can have significant consequences for lifetime reproductive success in a small bird that may experience only a few breeding events in its short life.

BLACK-CROWNED SPARROW-LARK. THE DESERT LARKS OF SAUDI ARABIA POSSESS SPECIALIZED SKIN CELLS THAT REDUCE WATER LOSS.

A BLACKSTART GAPES TO SHED HEAT THROUGH ITS MOUTH (MUCH LIKE A DOG PANTS TO SHED HEAT).

CASE STUDY 2: BLACKSTARTS, BALANCING SHADE AND SAFETY

A lack of trees combined with intense heat and sunlight means that finding suitable nest sites is especially challenging. Thus many Saudi Arabian birds nest in crevices in rocks, in hollows in trees, or in burrows in the ground. Nesting in crevices often provides an ideal thermal environment for raising young; however, unlike a typical cup-shaped or platform nest built in a tree, a nest at the end of a blind cavity leaves little chance for an adult bird to escape from a marauding predator that has found the nest. Consequently, cavity-nesting birds tend to be very cautious before entering their nest.

One cavity-nesting species that has special adaptations to reduce its risk of predation is the Blackstart. Nesting from March to July, these small birds build their cup-shaped nests at the end of a crevice up to 80 centimeters deep between large boulders on the ground or at the base of rock faces. These crevices provide an excellent micro-climate for raising young. For example, even in July when mean ambient temperature can fluctuate by 15°C between night (28.6°C) and day (44.2°C), the temperature of Blackstart nests inside a deep cavity remains remarkably constant, varying by less than 2°C around a near-optimal temperature (34.6–36.5°C).[9]

However, such cavities are accessible to a range of ground predators, including small mammals (especially Arabian Spiny Mouse and Golden Spiny Mouse), snakes, and lizards. As a result, the probability of a Blackstart nest surviving to fledging is less than one in three. Nests located more than 2.5 meters up a rock slope suffer less

Blackstart nests are vulnerable to attack by ground predators, including small mammals, snakes, and lizards. As a result, the probability of a Blackstart nest surviving to fledging is less than one in three.

TO AVOID HEAT, THIS THICK-BILLED LARK STANDS IN THE SHADE OF A BUSH; THE BREEZE BLOWS OVER ITS PARTLY OPENED WINGS AND EXPOSED, HEAVILY VASCULARIZED LEGS, HELPING TO COOL THE BIRD.

predation than nests built closer to the ground. Not surprisingly, these safer nest sites are taken by the larger, highest quality females. The smaller, poorer quality females have little choice but to nest in cavities close to the ground, which provide little chance for the adult to escape from a prowling predator.[10]

To help mitigate this intense predation pressure, ground-nesting Blackstarts have developed a remarkable adaptation: before laying her eggs, the female builds an impressive stone barricade or "rampart" to partially block the entrance to her nest cavity. One of the first reports of this behavior was from near Khamis Mushayt, where the birds had collected dozens of small stones to create a rampart near the nest entrance.[11] Further studies have since revealed that in order to build the rampart, the female spends 4–5 days collecting an average of more than 220 small flat stones, carrying them in her beak one at a time back to the cavity entrance, where, like a bricklayer, she places the pebbles in rows stacked three or four layers high. The wider the entrance to the nest cavity, the larger the rampart, with some containing hundreds of flat rocks. The largest stones weigh almost half the female's body weight and are carried from up to 25 meters away, sometimes at a rate of almost one stone per minute. On average, each female moves a total of almost 500 grams of rocks (more than 30 times her own body weight), eventually building a wall that reduces the dimensions of the cavity entrance by as much as two-thirds.[12]

Oddly, the rampart's most important function is to collapse and make a noise when a predator tries to enter the nest cavity. The sound of the stones clicking together or toppling acts as an unmistakable early warning system to alert the bird that a predator is approaching. Researchers have simulated the sound of a predator approaching a nest by pulling on a nylon thread that was tied to a pebble in a Blackstart's rampart. The sound of the pebbles clinking together caused the incubating bird to burst out of the nest instantly. Further, the predator is often forced to shift the pile of stones away from the cavity entrance in order to gain access to the nest, which buys the adult bird invaluable time to escape.[13]

Although the stone rampart may not stop the predator from eating the eggs or chicks, it allows the adult on the nest to live another day. As a further adaptation to very high nest predation rates, female Blackstarts have the extraordinary capacity to lay a replacement clutch within only four days of losing her previous nest.[14]

GROUND-FORAGING BIRDS SUCH AS THIS COMMON QUAIL ENDURE EXTREME HEAT RADIATING FROM THE BAKING DESERT SANDS DURING THE HEIGHT OF A SAUDI ARABIAN SUMMER.

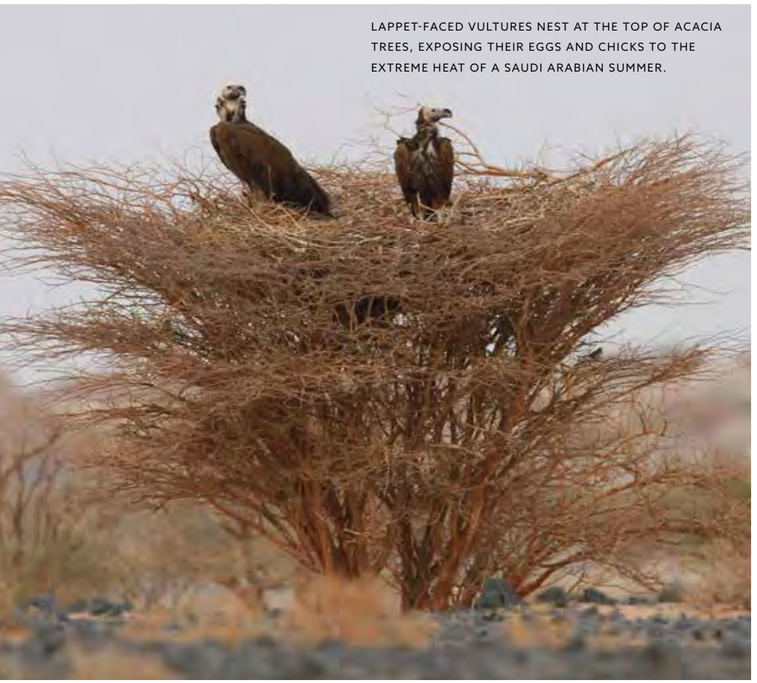
CASE STUDY 3: LAPPET-FACED VULTURES, BALANCING FOOD AND HEAT

Unlike most small birds, large bodied species cannot conceal their nest in secluded or inconspicuous places. Instead, they tend to nest on small islands, in cavities, or on cliff faces where they are generally safe from ground predators. Likewise, large-bodied species can avoid most ground predators by building their nest at the tops of trees; but in Saudi Arabia, nesting at the top of a tree fully exposes the chicks and adults to extreme sun and heat.

Perhaps the best example of a bird that braves the brute heat and aridity is the Lappet-faced Vulture. No bird spends more time exposed to the ruthless sun than this extraordinary vulture.

Perhaps the best example of a Saudi Arabian bird that braves the brute heat and aridity is the Lappet-faced Vulture. No bird spends more time exposed to the ruthless sun than this extraordinary vulture. This magnificent bird has been well studied at Emam Saud Bin Mohammed Protected Area where the temperature during the breeding season can exceed 48°C in the shade, while annual rainfall rarely exceeds 100 millimeters (range: 15–240 millimeters).

Lappet-faced Vultures build a huge stick nest (up to two meters in diameter and 50 centimeters deep) on the exposed crowns of Umbrella Thorn Acacia or Maerua trees, about 4–6 meters from the ground. Building this colossal nest (or repairing last season's nest) can take up to 30 days – enough time for some species to complete their entire nesting process. The female then lays a single, enormous egg (almost 10 centimeters long), which takes a further 55 days to hatch. The chick remains in the nest for an astonishing 130 days before finally fledging. Even then, the parents' work is not complete – the juvenile depends on the adults for food for another 4–5 months until it finally becomes independent.[15] In total, the nesting process can take up to 355 days (*see* Figure 3), and much of it occurs at the top of a flat tree that provides absolutely no shade whatsoever in one of the hottest, driest places on earth.



LAPPET-FACED VULTURES NEST AT THE TOP OF ACACIA TREES, EXPOSING THEIR EGGS AND CHICKS TO THE EXTREME HEAT OF A SAUDI ARABIAN SUMMER.

Not surprisingly, almost all aspects of the nesting behavior of the Lappet-faced Vulture is an adaptation to overcome the extreme conditions that it is inevitably confronted with throughout the epic nest attempt. First, the egg has to be laid as early as possible to ensure that the chick has sufficient time to fledge before the intense midsummer heat arrives. Thus, the female lays her egg in midwinter, a time when food availability is low and most other birds have no inclination to breed. Unlike many other species (which are triggered to breed following a flush of food or favorable weather) each female lays her egg on roughly the same date, year after year. For Lappet-faced Vultures, nesting is more akin to a marathon than a sprint – a transient event such as a downpour is inconsequential for a nesting process that extends for almost a year.[16]

Because the egg is developing during the coolest time of the year, it must be incubated constantly. Thus the parents synchronize their behavior to ensure that at least one bird is on the egg at all times. The egg typically hatches in late January or February, but can hatch as late as mid-April at some nests, at which point the weather is already becoming very warm. The chick hatches blind and naked; hence the parents must continue their grand vigil at the nest, helping the chick to thermoregulate for the next 45–60 days. Meanwhile the air temperature gets hotter and hotter with each passing week.

Thus for 100–115 days (55 days of incubation plus 45–60 days of brooding) at least one adult must be present at the nest at all times; this in turn means that each bird has on average 50% less time available to find food. The adults thus share information about where to find food. Evidence suggests that the male forages for much longer durations than the female, who endures longer bouts on the nest. The female watches while the male returns to the nest in a direct route from a supply of carrion, which may allow the female to retrace his flight path to locate the food source more efficiently.[17]

THE BROODING LAPPET-FACED VULTURE LOWERS ITS HEAD TO AVOID SUNLIGHT WHILE CASTING A COOLING SHADOW OVER ITS CHICK.

Throughout the entire nestling phase, the adults and the chick try to minimize heat stress. The adults almost always face away from the sun, and for the first three weeks after hatching, they physically move the naked chick so that it is positioned under the shade of the adult's body. But as the chick becomes larger and more mobile, the parent must spread one of its wings to shade the young bird. However, holding the wing out is energetically costly, and parents must drop their wing to rest about every 90 seconds.[18]

Once the chick is over 30 days old, the wing feathers begin to grow rapidly. By 45–60 days the chick is sufficiently feathered to survive exposure to sunlight; both parents immediately take the opportunity to refuel and to find yet more food for their growing offspring. For the next 70–90 days until it finally fledges, the chick spends almost all of its time by itself in the glaring sun. Without the parents to cast a relieving shadow, the young bird must now repel the direct sunlight of its own accord. Almost 95% of the time the chick stands with its back to the sun, its bare head held low in the shade of its own body, protecting its naked chest and legs. What little feathers it has are erected to increase both shade and airflow over the body. By May, the chick's wings noticeably droop as it struggles to endure the relentless heat.[19]

The majority of nestlings fledge in June or July, but those nests that started late must withstand several more weeks of extreme temperatures, with some not fledging until August or September when air temperatures creep towards 50°C.[20]

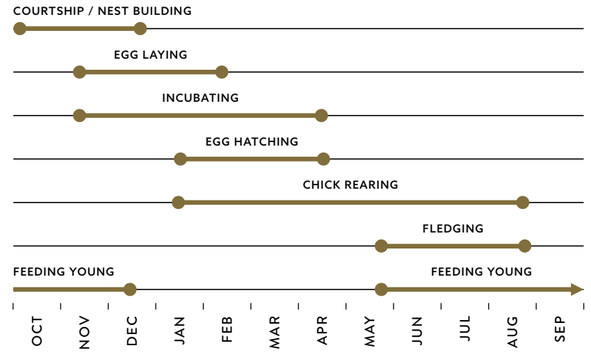


FIGURE 3: ANNUAL BREEDING CYCLE OF LAPPET-FACED VULTURES. THE SEASON BEGINS WITH COURTSHIP AND NEST BUILDING IN OCTOBER AND CONTINUES UNTIL THE FLEDGED YOUNG EVENTUALLY ACHIEVE FORAGING INDEPENDENCE SOME 12 MONTHS LATER.

Once the young vulture has achieved foraging independence, the adults have only a few short weeks until they must commence their next breeding attempt. Indeed, nesting is so arduous that many adults breed only every second year. Despite the attentiveness of the parents and the behavioral adaptations of the chicks, almost 50% of nests fail due to heat stress, starvation, predation or, most commonly, disturbance by humans.[21] Given the extreme hardships this species endures, we need to ensure our impacts on this extraordinary bird are eliminated.

WHITE-CHEEKED TERNS NEST ON THE GROUND ON ISLANDS OVER SUMMER, EXPOSING THEMSELVES AND THEIR CHICKS TO INTENSE HEAT.

Breeding terns fly low over the surface of the sea and repeatedly dip their bellies into the water, like a stone skimming across a pond. The adult tern returns quickly to the nest and uses its wet belly to cool its egg or chick.

CASE STUDY 4: WHITE-CHEEKED TERNS, BALANCING NEST PROTECTION AND HEAT

Another way that birds can reduce the risk of nest predation is by nesting on small offshore islands, which are generally free from ground predators. But again, this comes at a cost: low-lying offshore islands typically have scarce vegetation, meaning that most island-nesting species nest on open ground, exposed to the extreme Saudi Arabian weather. One such bird is the White-cheeked tern, which nests on islands in the Arabian Gulf and Red Sea. Like most seabirds in Saudi Arabia it nests not in spring but in summer when marine productivity (and air temperature) is at its highest.

The nesting behavior of these photogenic birds was studied in detail on al-Fanateer Island (near Jubail) in the Arabian Gulf where a colony of around 3,500 pairs breed from May to August every year.[22] Because of the lack of vegetation on the island, about two-thirds of all nests are exposed to direct sunlight throughout the unremitting Arabian summer months. Breeding adults spend almost all of their time sitting or standing at the nest battling strong winds, high humidity, and mean maximum daily temperatures in excess of 43°C in the shade. How do these birds ensure the survival of their nests in such grueling conditions?

Fortunately, seabirds have the luxury of being able to bathe in the sea; thus terns cool off by

A BREEDING WHITE-CHEEKED TERN DIPS ITS BODY IN THE WATER TO COOL ITS BROOD PATCH AND WET ITS BELLY FEATHERS.

standing at the water's edge and rocking their wings back and forth, splashing water over their head and body for instant relief. They also cool off by dipping their heavily vascularized feet into the water, sending cooled blood rapidly throughout the body.

However, while soaking in the water helps cool the adult, it does nothing to cool the eggs or chicks, which are left at the nest drenched in the fierce Arabian sun. To help their young survive the heat, adult terns carry seawater to the nest. That is, breeding terns will fly low over the surface of the sea and repeatedly dip their bellies into the water, like a stone skimming across a pond. The adult tern returns quickly to the nest and uses its wet belly to cool its egg or chick. The adult then stands over the egg and chick with its backs to the sun, sometimes with its wings open, to cast a shadow over the nest and allow the breeze to cool the freshly moistened nest. Similar belly soaking behavior has been observed in a number of tern species, as well as Kentish Plovers.[23]

To measure how effective this belly soaking behavior is, researchers installed miniature thermometers both on and in artificial tern eggs, which were then placed alongside real eggs in active nests. Miniature thermometers were also set up to measure ambient air temperature within the nest as well as ground surface temperature next to the nest. The thermometers were linked to a computer to record precise temperatures every ten seconds.[24]

The study revealed that the mean temperature of the ground surface near the nest was 43.5°C, with a maximum of 59.2°C, which is well above the lethal limit for birds. As ambient air temperature increased during the day, adult birds were forced to leave the nest significantly more often to engage in belly-soaking behavior. However, while the adult was soaking its belly in the water for only 30 seconds, the temperature of the exposed nest increased by 5.1°C, egg surface temperature increased by 2.8°C, and egg core temperature increased by 0.4°C (*see* Figure 4). However, these temperature increases were temporary: once the bird returned to the nest with a cool, wet belly, nest temperature decreased by 6.7°C within 3–4 minutes, causing egg surface temperature to drop by 4.2°C and core temperature to return to normal.[25]

This study demonstrates that the cooling effect of belly soaking reduces the temperature of the nest and egg and more than compensates for the brief temperature rise caused by vacating the nest – *provided the bird returns to the nest quickly*. Any excessive stress placed on the birds could be disastrous for their chances of breeding successfully. On one occasion during the study some people

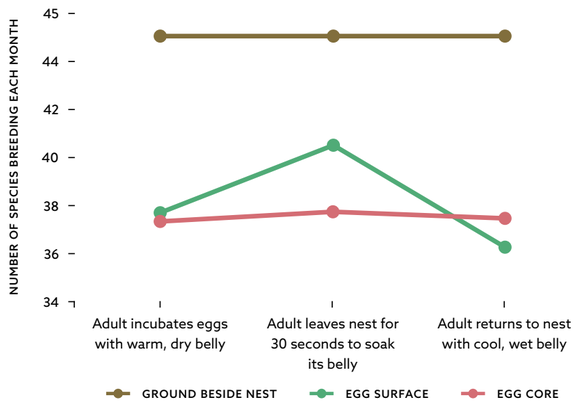


FIGURE 4: CHANGE IN NEST TEMPERATURES CAUSED BY WHITE-WINGED TERN BELLY SOAKING BEHAVIOR.[26]

arrived by boat unexpectedly and disturbed the breeding birds, which caused the entire colony at al-Fanateer Island to leave their nests for several minutes. As a result, mean nest air temperature increased by a whopping 8°C, causing the core temperature of the eggs to jump by almost 1°C. It took another 50 minutes before the incubating birds could cool the eggs to pre-disturbance levels.[27] Clearly, repeated disturbances at nesting colonies will cause egg failure and could even lead to colony collapse.

WITH ITS BELLY FEATHERS SOAKED, THE ADULT RETURNS TO THE NEST TO COOL ITS EGGS OR CHICKS.

THE MALE RÜPPELL'S WEAVER BUILDS SEVERAL NESTS HOPING TO ATTRACT AT LEAST ONE FEMALE TO HIS TERRITORY.

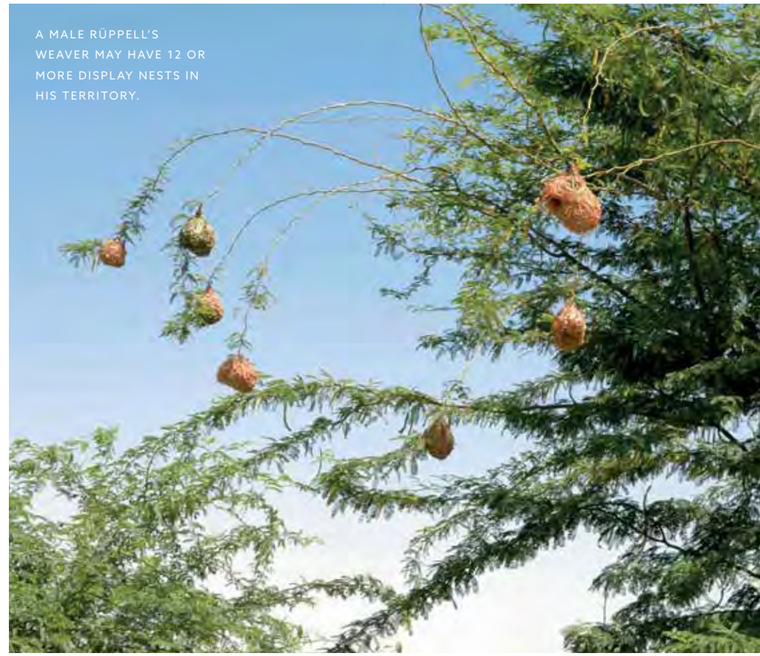
MATING STRATEGIES IN THE DESERT

One of the challenges of breeding is finding an appropriate mate. Each species has its own unique way of advertising its quality, attracting mates and repelling rivals. In this section, we focus on three common Saudi Arabian species to show that birds may try to attract mates using their song, their elaborate plumage, or by advertising their ability to hunt.

CASE STUDY 5: COMMON HOOPOE, ATTRACTING MATES WITH SONG

The Common Hoopoe's song is very simple: some say it sounds like, "*hoopoe... hoopoe... hoopoe...*". Others say it sounds like, "*hud hud... hud hud... hud hud...*". Hence, the bird is called the Hoopoe or Hud Hud in English and Arabic, respectively. This simple little song actually contains a great deal of information.

In hoopoes, only the male sings. He sings most commonly during pair-formation, nest-building and egg-laying, but reduces his singing rate by 50% once his mate has laid her eggs. This suggests that the main purpose of the hoopoe's song is to attract a female. Once the female has laid her eggs, the male stops singing and spends his time guarding the female and helping at the nest. He then



A MALE RÜPPELL'S WEAVER MAY HAVE 12 OR MORE DISPLAY NESTS IN HIS TERRITORY.

THE FEMALE RÜPPELL'S WEAVER INSPECTS THE NEST. IF SHE LIKES WHAT SHE SEES, SHE MAY BREED WITH THE RESIDENT MALE.

redoubles his singing rate when the chicks have fledged; that is, once he is available to breed again and hopes to attract another (or the same) mate to lay a new clutch.[28]

A FEMALE RÜPPELL'S WEAVER FEEDS HER FLEDGED YOUNG.

But how does singing a repetitive, monotonic song attract a female? Well, although birds appear to sing effortlessly, it actually requires considerable energy. Indeed, in many birds singing is second only to flight in terms of energetic cost. Significantly, there is subtle variation in the way male hoopoes sing their "*hud hud*" song. About 40% of males routinely sing songs containing only 2–3 notes – that is, their song consists of either "*hud hud*" or "*hud hud hud*", repeated over and over. But the heavier, healthier males sing songs containing four or five notes ("*hud hud hud hud hud... hud hud hud hud hud...*"). While the very best 4–5% of males sing songs containing six notes.

In the case of hoopoes, singing songs containing 4–6 notes causes a more rapid depletion of glycogen stores in the muscles, resulting in muscle fatigue. Underweight birds just don't have the energy to repeatedly sing 4–6 notes. They are simply too weak. If a weak male hoopoe is given additional food, he soon begins to sing 4–6 notes in his song. Thus, the song of a hoopoe is an honest signal of his current health.

THE MALE COMMON HOOPOE USES ITS SIMPLE 'HUD HUD' CALL TO ATTRACT MATES AND DETER RIVALS.

A PAIR OF VERY NEWLY FLEDGED COMMON HOOPOE CHICKS.

Although bird song appears effortless, it actually requires considerable energy. Indeed, in many birds singing is second only to flight in terms of energetic cost.

To test the hypothesis that females are attracted to males that sing more notes, researchers performed a simple experiment. First they recorded the songs of different hoopoe males – some that sang songs containing 2–3 notes, and others that sang songs containing 4–6 notes. Then at the start of the breeding season while pairs were forming, the researchers played the short-form song from a loudspeaker for five minutes; at the same time 100 meters away they also played the long-form song from another loudspeaker. Resident females would approach either of the loudspeakers, presumably to investigate this apparent "new male" in the neighborhood. The experiment was performed in many different territories throughout the study population. Over the course of the experiment, *five times* as many females went to investigate the loudspeaker that was playing the 4–6-note song compared to the speaker playing the 2–3-note song. This indicates that females truly do prefer males that sing more notes.[29]

Accordingly, males that sing 4–6-note songs usually get selected to breed, whereas males that only sing 2–3-note songs often miss out. Not only that, DNA fingerprinting reveals that females are almost always faithful to males that sing 4–5-note songs, but frequently unfaithful to males that sing 2–3-note songs.[30] A female that partners with a high quality male benefits. First, her offspring are likely to inherit the male's high quality genes. Second, the female and her nestlings receive significantly more food from the male during the breeding attempt, which increases the number of nestlings that fledge. Thus, there is great incentive for a female hoopoe to mate with a male that sings lots of notes, because this is a reliable indicator of his genetic quality and his parental ability.[31]

CASE STUDY 6: PALESTINE SUNBIRDS, ATTRACTING MATES WITH PLUMAGE

While female hoopoes select males on the quality of their song, female sunbirds select males on the basis of their iridescent plumage. These magnificent little birds lead quite incredible lives. At first glance, they appear to live simple lives: the male and females occur in socially monogamous pairs, all year round, year after year. Pairs build up to three nests in a season and can live for over eight years, which is quite long for such a tiny a bird (weighing only 5–7 grams). The female builds the nest and incubates the eggs herself, while both parents feed the chicks, clean the nest, guard against predators, and defend their small (one hectare) territory.[32]

But appearances can be deceiving. These sweet little birds are far from monogamous. When the DNA of adult and nestling sunbirds is examined, it becomes apparent that no less than 48% of the resident females are raising a nest that includes at least one young that is not fathered by her social partner. That is, at any one time virtually half of all female sunbirds are unfaithful.

Female sunbirds are fertile in the few days before they lay their eggs. During this period, males from neighboring territories, as well as unpaired males that have not established their own territory, will sneak into neighboring territories and try to impress the resident female by singing and showing off their colorful, iridescent plumage. During the breeding season, an average of three males enter any given territory every hour trying to court the resident female. In some cases, as many as five intruding males have been observed invading a single territory at the same time, all simultaneously trying to court the female. The resident female can choose whether or not to copulate with any of these interloping males.[33]

We are realizing more and more that not only are birds beautiful and elegant, they also lead incredibly fascinating and complex lives.

Of course, the resident male does not simply sit idly by and allow the intruders onto his territory. Instead, resident males spend a large percentage of their time defending their territories, acting aggressively towards other males, and closely guarding their mate. Scientists have conducted experiments in which the resident male was captured and temporarily removed from his

A COURTING MALE PALESTINE SUNBIRD.

ALMOST HALF OF ALL PALESTINE SUNBIRD NESTS CONTAIN AT LEAST ONE EGG THAT DOES NOT BELONG TO THE RESIDENT MALE.

A MALE PALESTINE SUNBIRD FEEDS A FLEDGED YOUNG, BUT HE MAY NOT BE ITS BIOLOGICAL FATHER.

territory. Almost instantly, the number of intruding males visiting the female increased by 600%! Each intruding male would immediately sing and begin displaying to the resident female. When the resident male was released and returned to his territory, the number of male intruders suddenly dropped again. Clearly males take the opportunity to sneak into a neighboring territory whenever the resident male is away.[34]

The females appear to have a great deal of control over mate choice in this species. Indeed, females will sometimes sneak away from their territory when they are fertile and visit neighboring males. On average, every territory in a population is visited by at least one female every two hours. Presumably she is assessing the quality of the resident males in the population.[35]

Males take a risk when they leave their own nest to pursue extra-pair copulations. Not only do they leave their female partner unattended, they also expose their chicks to attack. Occasionally, neighboring males will fly into an unguarded territory and kill the nestlings. The attacking male will peck at the young bird's head, stand on its back, or pull the tail feathers of the female to stop her feeding her young. If the resident male returns in time, he will attack the intruding male with great intensity; if he doesn't the chicks will die.[36] Females that lose their brood usually remain in their territories and start building new nests 2–7 days later. Hence, by committing infanticide, the attacking male is effectively triggering the female to become fertile again, potentially creating an opportunity to copulate with her. Alternatively, infanticide may be a strategy to trigger the resident pair to vacate the territory entirely. Similar infanticidal behavior has been observed in many mammal species, including lions, chimpanzees and bears, but is rare in birds.

While 48% of sunbird nests contain eggs that did not belong to the resident male, genetic studies have demonstrated that a further 6% of nests contain an egg that did not belong to the resident *female*. How is that possible? An intruding female (i.e., a neighbor or an unpaired female) surreptitiously lays her egg directly into another female's nest. The resident female simply looks after the extra egg as if it were her own. Females that deposit their eggs into a neighbor's nest tend to be those that have lost their own nest to predation during the pre-egg laying phase.[37] By depositing her eggs in another bird's nest, the intruding female gets the benefit of increasing her reproductive success without having to incur the extra costs of defending a territory and raising the young herself.

Although 90% of bird species live in socially monogamous pairs, genetic research indicates that some form of infidelity occurs in at least 90% of species, and that over 11% of offspring are, on average, the result of extra-pair paternity.[38] Why do birds, which appear to be monogamous, have such complex mating systems? In short, males may seek to increase their breeding success by siring offspring in other nests in addition to those they raise themselves. On the other hand, females may improve their own breeding success by choosing to produce offspring from males that are of higher quality than their social mates, or they may be insuring against male infertility. In both cases, each individual is trying to maximize its lifetime reproductive success.

We tend to find high levels of infidelity in species where the male is bright and significantly more ornamented than the female.[39] Interestingly, a recent global analysis has found a high frequency of such sexual dimorphism in Arabian birds.[40] Within Saudi Arabia, we might therefore find infidelity in several other highly dimorphic species, such as the Violet-backed Starling, Little Rock-thrush, Mourning Wheatear, Rüppell's Weaver, and many others.

The lovely Palestine Sunbird is a particular favorite with the public because of the male's bright coloration and the female's tendency to build her nests in suburban gardens. We are realizing more and more that not only are birds beautiful and elegant, they are also incredibly fascinating and complex.

A PAIR OF COMMON LITTLE BITTERNS BEGIN THEIR COURTING RITUAL.

GREAT GREY SHRIKES LEAVE PREY ITEMS IMPALED ON ACACIA THORNS TO ATTRACT MATES.

CASE STUDY 7: GREAT GREY SHRIKES, ATTRACTING MATES WITH RESOURCES

Many birds choose their partners based on the quality of their song or plumage – but some birds select their mate based on the quality of resources they possess, because these resources are a good indication of how good that bird is at hunting. This is the case in the Great Grey Shrike.

Shrikes have several characteristics in common with falcons. Both use their rapid flight to capture fast-moving prey (including other birds) in flight, and thus they both have protruding, forward-facing eyes, which provide them with the particularly acute vision necessary for hunting prey in motion. Shrikes also resemble falcons in having a sharp triangular-shaped ridge (called the "tomial tooth") on the outer edges of the upper mandible. Both use this ridge to bite the neck of their prey to sever the vertebrae, thereby killing their prey quickly.

However, unlike raptors, shrikes lack a crop to temporarily store food before digestion and cannot ingest large prey items in a single meal. Further, while shrikes and raptors both have relatively strong feet, shrikes lack the strong talons that falcons use to capture and dismember their prey. So if shrikes cannot swallow large prey whole and they have difficulty tearing apart a freshly killed vertebrate, then how do they consume their food? They have developed a rather macabre solution to the problem.

Shrikes *impale* their prey on the thorns of acacia trees, on spiky twigs or on barbed wire fences. With the prey skewered, they can more easily slice and dissect it using the distinctive sharp hook on the end of their beak. This grisly trick enables shrikes to capture and exploit much larger prey species than we might expect for a relatively small bird. Shrikes will also impale poisonous invertebrates (like some grasshoppers), leaving them for several days until the grasshopper's toxin slowly degrades, rendering the insect harmless. Again, this behavioral trait allows shrikes to exploit prey that would otherwise be unavailable to them.

Great Grey Shrikes often leave the dead animal impaled on the thorn of an acacia tree for several days or weeks. Sometimes 14 or more food storage sites can be found at any one time within the bird's territory. The shrikes store their dead prey in these "larders" when food is abundant in case of future shortages or in preparation for the breeding season when food demands are greatest. Of course there is always the risk that another bird or animal will find the cached food and eat it before

Male shrikes leave some of their prey impaled on thorns to advertise how capable they are at finding food – this is how they attract their mates.

AN INCUBATING CHESTNUT-BELLIED SANDGROUSE. THE NEST IS SIMPLY A SCRAPE ON THE GROUND.

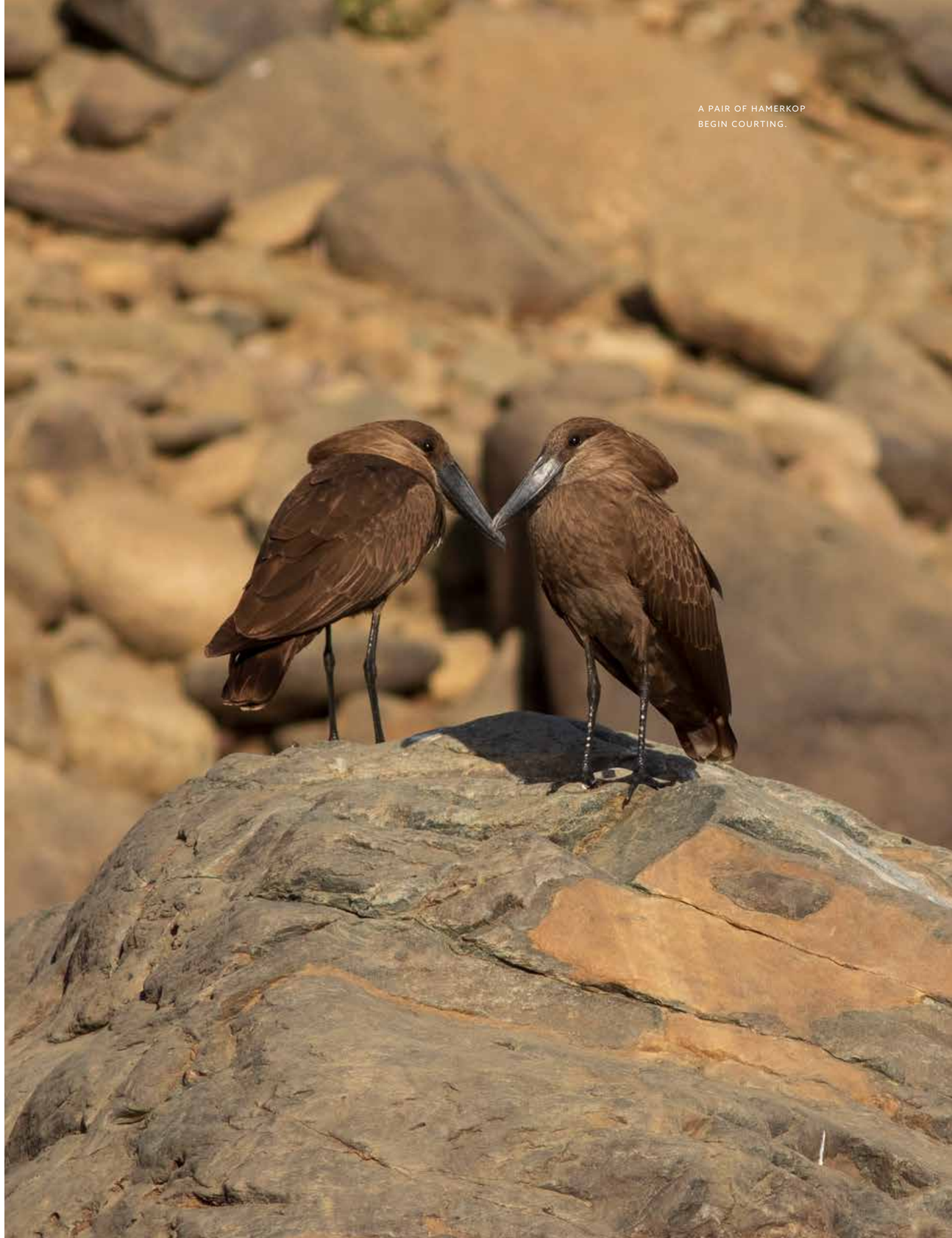
the shrike does. To reduce the cost of its cached food being stolen, the shrike often decapitates the impaled prey and eats the brain – the most valuable part of the prey – as soon as it can, leaving the less valuable, headless body for later.

There is an interesting difference in the way that male and female shrikes treat their prey. Female shrikes usually store their impaled prey deep within large, dense bushes, thereby hiding it from other birds. In addition, the females tend to eat their stored food within a few days of impaling it. In contrast, male shrikes often impale and store their prey for long periods and in very conspicuous places within their territory (such as on barbed wire fences, the tops of trees, or on solitary upright twigs), especially during the mating and courtship periods. In one study, males impaled over 90% of prey in very visible locations at the start of the breeding season, but by the nestling phase they will have concealed almost half of their prey.[41] Clearly, male shrikes store their prey in highly visible places at least partially as a visual signal to other birds.

By placing food around their territory in the lead up to the breeding attempt, the males are able to advertise how capable they are of finding food, how skillful they are at impaling it, how much additional food they have in their larder, and how well they can defend the impaled items. From a female shrike's perspective, these are all very attractive traits in a potential mate.

A TRADITIONAL NEST OF AN OSPREY ON TARUT ISLAND.

A PAIR OF HAMERKOP BEGIN COURTING.



THE COLOSSAL NEST OF A HAMERKOP.

To confirm whether females were attracted to males with large food stores, researchers randomly allocated shrike territories within their study population into three different groups: (i) at some of the territories the researchers systematically removed all of the food stored by the males; (ii) at other territories, the researchers artificially increased the amount of food stored by 25% by placing dozens of dead insects and mice on the thorns within the shrikes' territories; and (iii) at the remaining territories the researchers simply left the stored prey items as they were. The scientists then compared the breeding success of the males within these three groups.

Females clearly preferred to mate with males that had artificially elevated amounts of food stored on thorns within their territory. On average, females mated one month earlier with males at those sites where the amount of food impaled on visible thorns was artificially enhanced compared to sites where males had normal amounts of impaled food. Not only that, the males with artificially enhanced food stores were more likely to mate with multiple females and fathered three broods each per season, compared to only one or two broods for the males in unmanipulated territories. Finally, females that mated with males with elevated food resources produced on average 88% more eggs than the females who paired with average males. As for those males that had all of their food removed? Well, they did not get to mate at all.[42] Clearly, the males with the most advertised resources were most desirable to the females.

If you find a nest, the most important thing to remember is to minimize any disturbance caused to the birds.

CONCLUSION

A wonderful variety of nests can be found within Saudi Arabia, ranging from a nightjar's simple scrape in the ground to the colossal, complex nest of the Osprey or Hamerkop. An equally extraordinary range of nesting behaviors can also be observed. If a nest is discovered, always consider the Birdwatcher's Code discussed at the start of this book. The most important priority is to minimize any disturbance caused to the birds. Some species will abandon their nest if there is even a slight disturbance.

Enjoy briefly observing and photographing the nest, but come and then go as quickly and as quietly as possible to allow the adult birds to resume their urgent parental care – otherwise the eggs and chicks can suffer from heat stress, starvation, or predation. As described above, nesting in Saudi Arabia is extremely difficult and precarious, and any nest lost to human carelessness is a tragedy.

When we see a pair or group of birds nesting in Saudi Arabia, be they a pair of larks nesting in the middle of the desert, or a colony of cormorants nesting on a tropical island, let's appreciate them for what they are: dutiful parents risking their lives for their offspring, fragile eggs incubating in a tightrope of temperature, and defenseless, naked, blind and hungry chicks waiting for the chance to take their first flight. It is essential that we give these local heroes all the resources they need to breed and to support them by keeping their precious nesting areas intact.

A KENTISH PLOVER CHICK LEAVES THE NEST DAYS AFTER HATCHING.

CHAPTER 5

The Challenges of Migrating Through Saudi Arabia

GRIFFON VULTURES SOARING HIGH OVER THE 'ASIR MOUNTAINS AT TANUMAH.

KEY POINTS

- The Arabian Peninsula lies at the intersection of three major global migratory flyways.
- As a result, Saudi Arabia regularly hosts 291 species of migratory birds from Africa, Europe, Asia, the Indian subcontinent, and even North America.
- Many species come to the Kingdom to breed or to spend the winter; others pass through on their way to distant breeding or foraging sites.
- Some species migrate as much as 30,000 kilometers each year, navigating by the sun, stars, and magnetic fields.
- Migratory birds literally race across the world to win the best breeding sites.
- Saudi Arabia is an important host to migratory birds; we should provide safe passage for these visiting dignitaries.

THE WILLOW WARBLER MIGRATES UP TO 24,000 KM PER YEAR, YET IT WEIGHS ONLY 15 GRAMS.

Around 16% of the world's migratory bird species pass through Saudi Arabia annually, underlining the importance of the Kingdom for global biodiversity.

THE MIRACLE OF MIGRATION

Is there any feat of endurance more astonishing than that of a tiny bird racing across thousands of kilometers of deserts, mountains, cities, and oceans in search of a place to breed? Consider, for example, the extraordinary Willow Warbler: standing only 12 centimeters tall and weighing only 10 grams these tiny birds migrate from sub-Saharan Africa to nest up to 12,000 kilometers away, with thousands passing through Saudi Arabia in April and May. Eventually they reach their breeding grounds across northern Eurasia with some travelling as far as the northeast coast of Russia. Those that survive the journey almost immediately begin to build their nest, often merely centimeters from their nest of the previous year. As remarkable as that is, consider the chicks: only a few days out of the nest, they spontaneously respond to an irresistible urge to fly across the equator to find their foraging grounds in Africa 12,000 kilometers to the south, passing through Saudi Arabia in September and October. If they survive, these diminutive birds will have flown more than 24,000 kilometers in just six months. It all seems truly miraculous.

And yet despite how improbable these epic journeys seem, migration is not uncommon. Around 19% (1,855) of the world's 9,856 bird species migrate annually (that is, they make regular cyclical movements beyond their breeding distribution, with predictable timing and destinations).[1] Within Saudi Arabia, the percentage of migratory species is significantly higher: of the 401 native species regularly recorded in Saudi Arabia, 291 (73%) contain at least some populations that migrate to or through the Kingdom.[2] In total, around 16% of the world's migratory bird species pass through Saudi Arabia annually, underlining the importance of the Kingdom for global biodiversity.

EURASIAN BUZZARD, ONE OF 291 MIGRATORY BIRD SPECIES THAT VISITS SAUDI ARABIA EACH YEAR.

WHY DO BIRDS MIGRATE?

Why do so many birds undertake these energetically costly and perilous journeys? Generally, birds migrate to exploit reliable patches of abundant but ephemeral resources. For example, many of the migratory species that arrive in Saudi Arabia nest in the temperate, boreal or arctic regions of northern Eurasia during spring and summer where the long, mild days support rapid plant growth and vast numbers of invertebrates. In spring and summer the steppes of western Asia are literally buzzing with locusts and grasshoppers. There, birds can find the extra food and the long days needed to feed their hungry chicks. However, these prime conditions are short-lived. Inevitably the bleak northern winter will return, forcing these birds to leave their breeding grounds before the days become short, the weather turns cold, and the food is depleted. Hence the adults and their new offspring fly south to areas that offer better conditions, such as the tropics or the temperate biomes of the Southern Hemisphere.

Other migratory species nest at high altitudes, again benefitting from the flush of spring productivity that follows an alpine winter; but they too must migrate (typically to low-lying areas nearby) before the winter frosts arrive. Many seabirds also migrate, usually to follow seasonal spikes in marine productivity and also because they must return to land to build their nests. In short, birds will migrate to exploit temporary food resources provided the reproductive benefits outweigh the energetic costs of migration.

A LESSER GREY SHRIKE RESTS IN DHAHRAN HILLS DURING ITS 12,000 KM MIGRATION FROM SOUTHERN AFRICA TO EASTERN EUROPE.

The impressive diversity of migratory birds recorded in Saudi Arabia is largely a result of global biogeography. The Arabian Peninsula lies at the crossroads of Africa, Europe, Asia and the Indian subcontinent. As a result, millions of *passage migrants* fly over Saudi Arabia each year as they migrate between these major landmasses. Further, because Saudi Arabia is located in the northern tropics, it hosts species from the north that choose to winter in the Kingdom (known as *winter visitors*), as well as species from the south that choose to nest here (known as *breeding migrants*).

Birds will migrate to exploit temporary food resources provided the reproductive benefits outweigh the energetic costs of migration.

GREATER FLAMINGOES ARE A COMMON PASSAGE MIGRANT AND WINTER VISITOR TO SAUDI ARABIA'S COASTS.

THE DELICATE SPOTTED FLYCATCHER IS ONE OF 196 PASSAGE MIGRANTS THAT TRAVEL THROUGH SAUDI ARABIA EACH YEAR.

WHEN DO BIRDS MIGRATE TO SAUDI ARABIA?

PASSAGE MIGRANTS

Most passage migrants fly through the Kingdom twice per annum (*see* Figure 1) en route between their breeding and non-breeding grounds. The majority of Saudi Arabia's passage migrants nest in Eurasia and spend the winter several thousand kilometers to the south in Africa or sometimes India. In total, 196 species have populations that pass through the Kingdom annually. As demonstrated in Figure 1 most passage migrants pass through the Kingdom in spring and autumn. Interestingly, Figure 1 reveals that more passage migrant species appear to pass through the Kingdom in spring compared to autumn. The reason for this trend is unclear. Perhaps there are unfavorable wind currents across the Arabian Peninsula in autumn, or perhaps many species are unable to find suitable food resources in the Kingdom in autumn at the end of another long, hot Arabian summer.

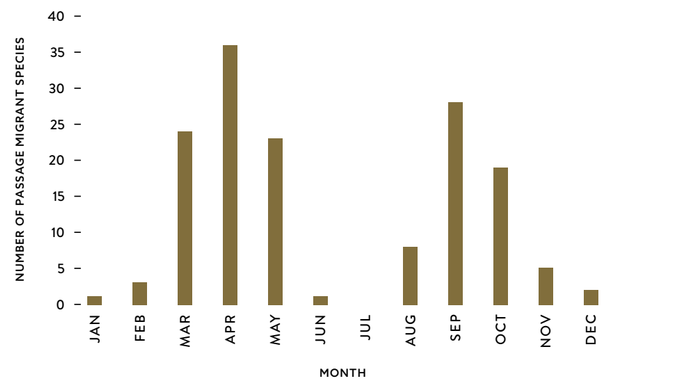


FIGURE 1: MONTHLY FREQUENCY OF PASSAGE MIGRANT SPECIES IN SAUDI ARABIA.

THE BLACK-WINGED STILT IS A COMMON PASSAGE MIGRANT AND WINTER VISITOR TO SAUDI ARABIA.

WADERS ARE ONE OF THE MOST MIGRATORY GROUPS OF BIRDS. HERE A MIXED FLOCK PASSES ALONG THE ARABIAN GULF COAST NEAR JUBAIL.

A PAIR OF MIGRATORY TEMMINCK'S STINTS COMPETE AGGRESSIVELY FOR A WINTER FEEDING TERRITORY.

WINTER VISITORS

Winter visitors breed outside of Saudi Arabia (primarily in Eurasia) before migrating south to spend the winter months within the Kingdom (*see* Figure 2), where they attempt to find as much food as possible in order to prepare for the upcoming return migration and subsequent breeding season. In total, 206 migratory species have populations that spend the winter in Saudi Arabia.

The impressive Cinereous Vulture is a fine example of a winter visitor to Saudi Arabia. In spring, it breeds in multiple areas across Eurasia, from Portugal to Mongolia. As the weather begins to cool many birds from the eastern populations migrate south and west to spend the winter in

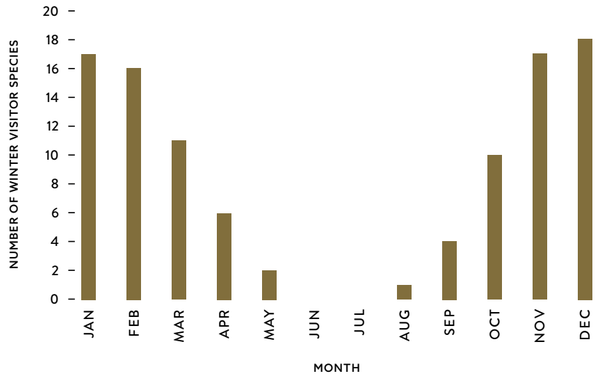


FIGURE 2: MONTHLY FREQUENCY OF WINTER VISITORS IN SAUDI ARABIA.


AFTER BREEDING, SOME EURASIAN SCOPS-OWLS MIGRATE SOUTH TO SPEND THE WINTER IN SAUDI ARABIA.

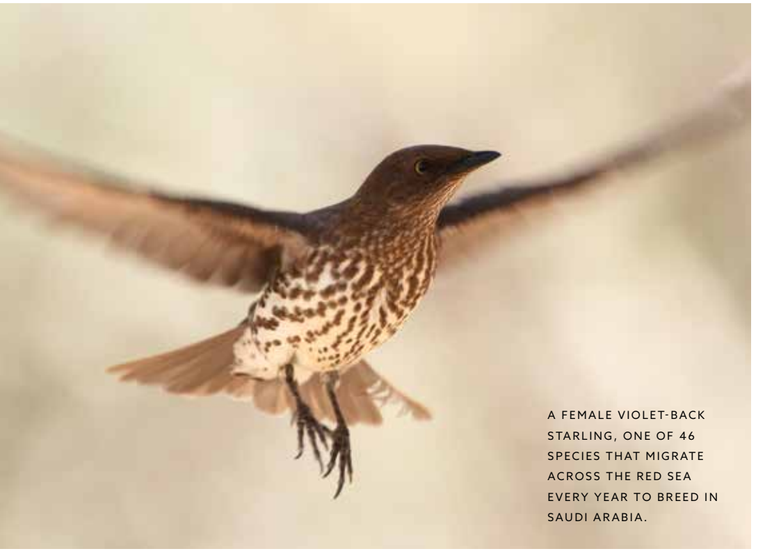
LARGE NUMBERS OF COMMON STARLING MIGRATE FROM EUROPE TO SPEND THE WINTER IN THE NORTHERN HALF OF THE KINGDOM.

CINEREOUS VULTURE. SOME OF THE JUVENILES BORN IN TURKEY, GEORGIA AND ARMENIA WILL SPEND THEIR WINTERS FORAGING BETWEEN RIYADH AND HAFAR AL-BATIN.

India or Saudi Arabia. Satellite-tracked juveniles from nesting populations in Turkey, Armenia and Georgia migrate south to the northern plains of Saudi Arabia (generally between Riyadh and Hafar al-Batin) where at least some remain for the winter.[3]

Some of the winter visitors to Saudi Arabia are altitudinal migrants: that is, they nest at high elevations but migrate to lower areas nearby for the winter. For example, the Kurdish Wheatear, Red-tailed Wheatear, and Finsch's Wheatear all nest in the Zagros Mountains up to 4,000 meters above sea level, before migrating only 300 kilometers across the Arabian Gulf to spend the winter in Saudi Arabia and surrounding areas.

EVERY YEAR, VAST NUMBERS OF SEABIRDS SPEND THE WINTER ALONG SAUDI ARABIA'S COASTLINES.

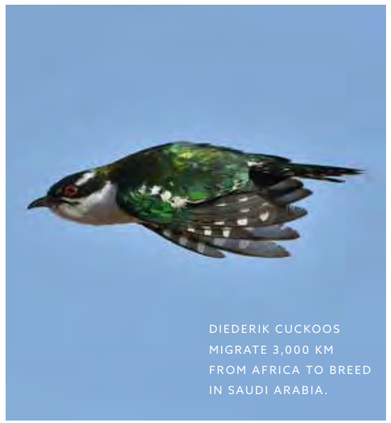


A FEMALE VIOLET-BACK STARLING, ONE OF 46 SPECIES THAT MIGRATE ACROSS THE RED SEA EVERY YEAR TO BREED IN SAUDI ARABIA.

BREEDING MIGRANTS

Breeding migrants arrive in Saudi Arabia, attempt to breed, and then return to their non-breeding grounds. In total, 46 species have populations that regularly migrate to Saudi Arabia to breed.

Most of the Kingdom's breeding migrants spend the non-breeding season (October–February) in Africa south of the equator, where it is summer, before migrating to the northern tropics to breed (*see* Figure 3). One such species is the White-throated Bee-eater. About 1,000 breeding pairs migrate from their non-breeding grounds just south of the equator (between The Gambia and Uganda) to their breeding grounds just north of the equator, arriving in southwest Saudi Arabia around April. These ornate birds establish their nest sites around May, and by September breeding pairs can be seen returning to Africa, often accompanied by their young. They spend the next six months foraging in their African non-breeding grounds before returning once again to Saudi Arabia.



DIEDERIK CUCKOOS MIGRATE 3,000 KM FROM AFRICA TO BREED IN SAUDI ARABIA.

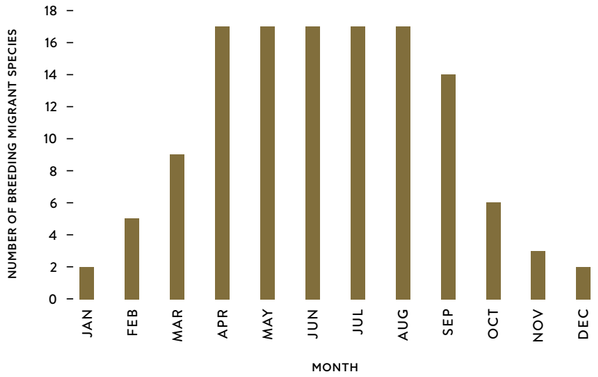
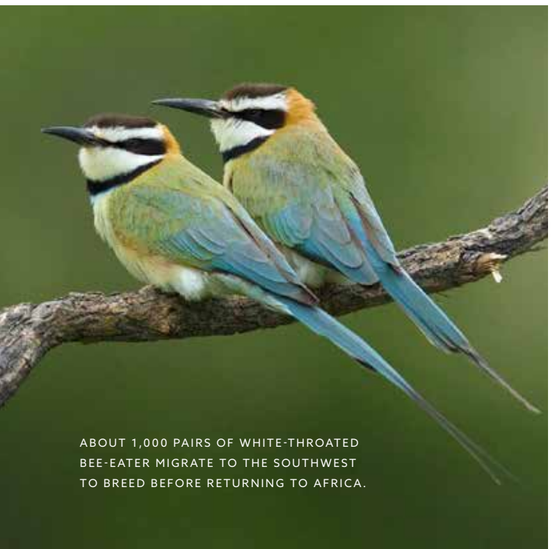


FIGURE 3: MONTHLY FREQUENCY OF BREEDING MIGRANTS IN SAUDI ARABIA.



ABOUT 1,000 PAIRS OF WHITE-THROATED BEE-EATER MIGRATE TO THE SOUTHWEST TO BREED BEFORE RETURNING TO AFRICA.

A BRIDLED TERN CHICK LEAVES THE NEST JUST DAYS AFTER HATCHING. IN A FEW SHORT WEEKS, IT WILL MIGRATE TO THE INDIAN OCEAN WHERE IT WILL SPEND THE WINTER FORAGING AT SEA.

SOME MASKED SHRIKES PASS THROUGH THE KINGDOM WHILE OTHERS SPEND THE WINTER HERE, ESPECIALLY IN THE FOOTHILLS IN THE SOUTHWEST.

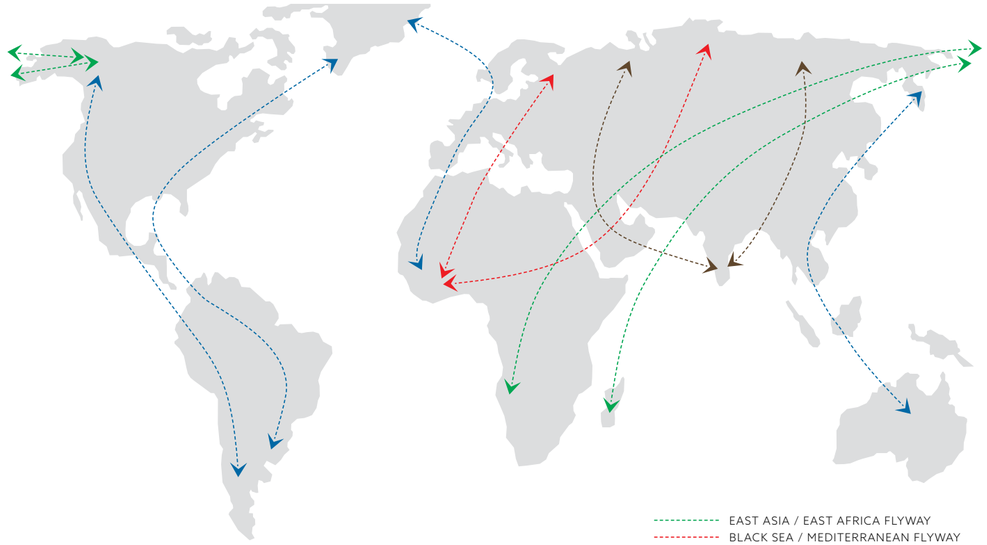


FIGURE 4: MAP OF GLOBAL FLYWAYS.

WHERE DO SAUDI ARABIA'S MIGRATORY BIRDS COME FROM?

Populations of different migratory species often utilize broadly similar flight paths. For instance, many species may follow the same landscape features such as coastlines or mountain ranges, avoid the same deserts, or funnel into the same mountain passes, land bridges or narrow straits. A collection of similar flight paths is known as a flyway, which is a useful concept for helping to define the annual movement of birds globally. As illustrated in Figure 4, eight major flyways have been identified.

One of the reasons why Saudi Arabia receives so many migratory species is that three major flyways pass over the Arabian Peninsula, namely: (i) the East Asia / East Africa Flyway; (ii) the Black Sea / Mediterranean Flyway; and (iii) the Central Asia / South Asia Flyway. These three flyways bring an array of birds to Saudi Arabia from seemingly disparate regions of the world.

One of the reasons why Saudi Arabia receives so many migratory species is that three major flyways pass over the Arabian Peninsula bringing birds into the Kingdom from seemingly disparate regions of the world.

EAST ASIA / EAST AFRICA FLYWAY

Saudi Arabia receives huge numbers of birds migrating along the East Asia / East Africa Flyway, which runs from southern Africa to northeast Asia and across the Bering Strait to North America, a vast area that encompasses 64 countries.[4] It may seem odd that birds nesting in central Russia would fly southwest to Africa rather than simply due south to southern Asia, but in fact it is a sensible strategy: by travelling southwest, migrating birds avoid the Tibetan plateau and Himalayas, which are formidable obstacles to migration considering the low oxygen environment of such high altitudes.

Several billion birds from 331 species utilize part or all of this flyway every year, making it the second busiest flyway in existence. About 226 of these species have populations that regularly pass through Saudi Arabia, making this the most important flyway for Saudi Arabia (*see* Figure 4).[5]

BLACK SEA / MEDITERRANEAN FLYWAY

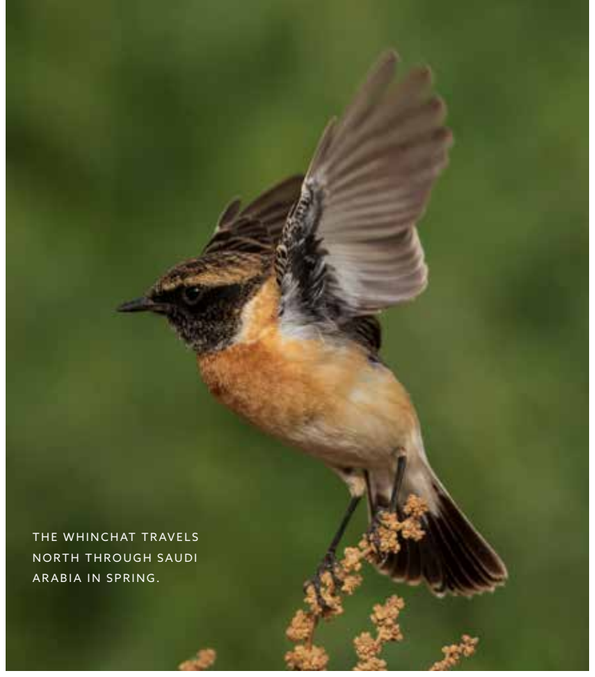
Saudi Arabia also receives birds that migrate along the western edge of the Black Sea / Mediterranean Flyway, which runs more or less north-south from Arctic Europe and western Russia, over the Mediterranean and Black Seas, to southern Africa, an area encompassing 101 countries.[6] Many species avoid the twin obstacles of the Mediterranean Sea and the Sahara Desert by passing through Turkey into Arabia and south along the Red Sea coast. This has the effect of bringing such distinctly "European birds" as the European Robin, Cyprus Wheatear, Sardinian Warbler and Olive-tree Warbler, among many others. An estimated 2.1 billion individual birds from 302 species utilize part or all of the Black Sea / Mediterranean Flyway. Around 147 of these species regularly fly to or through Saudi Arabia (*see* Figure 4).

THE BARN SWALLOW MIGRATES ALONG THE EAST ASIA / EAST AFRICA FLYWAY.

Remarkably, many small songbirds undertake the marathon journey along the Black Sea / Mediterranean Flyway. The Marsh Warbler, for example, breeds in Central Europe during the northern summer before embarking on an 8,000-kilometer journey south to its non-breeding grounds in southeastern Africa, with many passing through Saudi Arabia in August and September. From October to March it enjoys the southern summer in its non-breeding grounds in Zambia and surrounding countries, before returning to breed in the north, passing through Saudi Arabia once again in April and May. In the space of less than six months these tiny birds fly more than 16,000 kilometers, and yet they only weigh about 12 grams – less than a tablespoon of water.

A number of species using this flyway migrate in a loop: they leave their European breeding grounds in autumn by flying south through Africa, but return to their breeding grounds in spring by heading north through Arabia. Red-backed Shrikes, Lesser Grey Shrikes, Willow Warblers, Marsh Warblers, Garden Warblers, Great Reed-warblers, Spotted Flycatchers, Whinchats, Thrush Nightingale, and several other species all take this 1200-kilometer detour across the Arabian Peninsula, which results in a migratory circuit that is 22% longer than a simple linear return migration.[7]

A EUROPEAN HONEY-BUZZARD MIGRATING THROUGH SAUDI ARABIA ALONG THE BLACK SEA / MEDITERRANEAN FLYWAY.



THE WHINCHAT TRAVELS NORTH THROUGH SAUDI ARABIA IN SPRING.

Loop migration is probably a response to climatic conditions in Africa and Arabia. Birds migrate south through Africa in early autumn when much of central Sudan is green and inviting, while the Arabian Peninsula is dry and extremely hot. In spring, on the other hand, Sudan is dry, while rain has generally arrived in southern Ethiopia and southern Somalia, and green conditions can be found in southwestern Oman and around the Arabian Gulf. In addition, wind conditions in spring may be more suitable for northward migration in Arabia than in Africa, while the reverse holds true for the autumn migration.[8] In combination, these conditions serve to bring yet more migratory species to Saudi Arabia.

Geolocators placed on Red-backed Shrikes indicate that these birds spend early spring fattening up in Ethiopia before crossing the Bab al-Mandab Strait and then heading north through the center of Saudi Arabia, travelling 233 kilometers per day on average. The shrikes make frequent but short stopovers along the way to restore their fat reserves, a strategy that requires favorable feeding conditions across the entire migratory route. Losing some of these feeding sites could prove disastrous for the spring migration of Red-backed Shrikes, a species that is in decline globally.[9]

CENTRAL ASIA / SOUTH ASIA FLYWAY

Finally, Saudi Arabia also receives birds that migrate along the Central Asia / South Asia Flyway, which runs from arctic Russia in the north to the Indian subcontinent in the south. Covering 29 countries, it is the shortest flyway in the world.[10] While some birds utilizing this flyway are able to pass over the Himalayas and Tibetan Massif, most circumvent these obstacles by flying to the east through China or to the west along the Caspian Sea, and south along the Arabian Gulf to India, with the result that many species pass through Saudi Arabia.

Around 307 species migrate along the flyway annually, and 130 of these regularly enter Saudi Arabia (*see* Figure 4). Even though it is the shortest flyway, some birds still migrate a considerable distance along its corridor. For example, Red-breasted Flycatchers breeding as far west as Sweden and Austria migrate 7,000 kilometers to winter in the Indian subcontinent; some pass through Saudi Arabia, where they occasionally

THE RED-BACKED SHRIKE MIGRATES IN A LOOP, FLYING SOUTH THROUGH AFRICA IN SPRING AND NORTH THROUGH SAUDI ARABIA IN AUTUMN.

COMMON SHELDUCK MIGRATE ALONG THE CENTRAL ASIA / SOUTH ASIA FLYWAY TO WINTER IN SAUDI ARABIA.

spend the winter. Conversely, several species breed within the Indian subcontinent and migrate *north* along the flyway for the winter, bringing several "south Asian birds" to the Kingdom, including the spectacular Oriental Honey-buzzard.

The combined breeding and non-breeding distributions of birds that migrate to or through Saudi Arabia covers a great proportion of Europe, Africa, Asia, and the Indian subcontinent, as well as some of North America. This simple fact has a very significant implication: activities in Saudi Arabia can affect ecosystems and communities across much of the globe.

HOW DO BIRDS MIGRATE?

Birds migrate using one of two flight modes: (i) powered flapping flight or (ii) soaring and gliding. Most small or medium-sized birds migrate using flapping flight. Indeed, about 89% of the 291 migratory species that migrate to or through Saudi Arabia use flapping flight, including most of the migratory passerines and waders. In contrast, most large birds tend to migrate by soaring and gliding. In total, 31 species migrate across Saudi Arabia primarily by soaring and gliding, including the cranes, storks, ibis, the larger hawks, eagles, and vultures. The mode of flight used by birds has a profound effect on their migration strategy.

FLAPPING MIGRANTS

Flapping flight is perhaps the most energetically costly form of locomotion on earth. Consequently, species that migrate long distances using flapping flight (primarily songbirds and waders) have adaptations that minimize the energetic costs of flight. For example, many internal organs are significantly smaller in long-distance migrants compared to short-distance migrants or sedentary species. A recent analysis of 149 migratory species found that the weight of the gizzard, liver and even the heart is significantly reduced in long-distance migrants.[11]

Long-distance flapping migrants generally have long, narrow, pointed wings and short, square tails (exemplified by many waders), which according to aerodynamic theory reduce the amount of physical exertion needed to sustain straight-line flight. In contrast short-distance migrants or sedentary species tend to have shorter, more rounded wings and long and graduated tails (such as ravens), which allow rapid takeoff, greater aerial maneuverability, and short bursts of powerful flight.[12]

Flapping flight is perhaps the most energetically costly form of locomotion on earth. Consequently, long distance migrants have a suite of adaptations to minimize the energetic costs of flight.

THE LONG TAPERED WINGS OF THE SLENDER-BILLED GULL IS CHARACTERISTIC OF MIGRATORY SEABIRDS.

HEAVY BIRDS LIKE THE GREATER WHITE-FRONTED GOOSE MIGRATE VERY SLOWLY, TRAVELLING ONLY 25 KM IN NINE HOURS OF FLIGHT.

The same general pattern of wing specialization can be found when comparing species within the same genera. For example, wheatears that migrate long distances across Arabia (such as Northern Wheatears and Isabelline Wheatears) have long pointed wings, while their sedentary counterparts (Buff-breasted Wheatear and the Arabian Mourning Wheatear) have more rounded wings.[13]

As birds get larger, the energy required to power their flight becomes greater and greater. As a result, larger birds that use flapping flight tend to migrate very slowly.[14] Thus perhaps surprisingly, large and seemingly powerful birds like the Greylag Goose or Greater White-fronted Goose migrate only 25–30 kilometers in nine hours of migratory flight, whereas much smaller birds, such as many of the warblers and wheatears, are able to cover 5–10 times that distance in the same amount of time. Indeed, Great Snipe can average 1700–2150 kilometers per day for up to four days in a row.[15]

ISABELLINE WHEATEARS THAT MIGRATE HAVE LONG POINTED WINGS FOR DISTANCE FLIGHT, WHEREAS RESIDENT POPULATIONS HAVE SHORT, ROUNDED WINGS FOR AGILITY.

DEMOISELLE CRANE SOAR ACROSS THE KINGDOM IN V FORMATIONS RARELY FLAPPING THEIR WINGS.

Soaring migrants look utterly majestic with their colossal wings outspread: the wingspan of the Steppe Eagle can measure 200 centimeters, the Griffon Vulture 280 centimeters, while the wingspan of the Cinereous Vulture can reach three meters.

SOARING MIGRANTS

For large birds, powered flapping flight is simply too expensive to sustain. Indeed, very large birds would need to store so much fuel that it would be impossible for them to remain airborne. Thus, large birds like Eurasian Buzzard (427–1360 grams), White Stork (2300–4400 grams) and Cinereous Vulture (7000–12500 grams) tend to adopt soaring flight: that is, they circle high into the air on thermal currents using their broad, outstretched wings, before gliding for hundreds of meters in search of the next thermal updraft. This soaring and gliding flight allows large birds to migrate at speeds around 200 kilometers per day.

The wings of soaring migrants are specialized to maximize loft: they are very long and (unlike the narrow, tapered wings of flapping migrants) very broad. This presents a huge winged area, allowing the bird to remain suspended in the air like a kite. Consequently, soaring migrants in Saudi Arabia look utterly majestic with their colossal wings outspread: the wingspan of the Grey Heron approaches 195 centimeters, the Steppe Eagle 200 centimeters, the Griffon Vulture 280 centimeters, while the wingspan of the Cinereous Vulture can reach three meters.

By riding on updrafts soaring migrants climb hundreds of meters into the air. While crossing the deserts of Arabia, the Steppe Eagle, for example, can soar up to eight kilometers above ground level; however, most of the time it flies below 1000 meters, and indeed half of its soaring occurs below 400 meters, much to the delight of birdwatchers across the Kingdom.[16]

Although soaring flight may appear effortless, the metabolic rate of soaring birds is actually 2–3 times higher than at rest.[17] Nonetheless, for larger birds the energetic cost of soaring flight is still dramatically lower than the cost of flapping flight. For example, for a very large bird like the Cinereous Vulture (weighing up to 12.5 kilograms), energy consumption is 50 times higher in flapping flight compared to soaring flight.

EURASIAN BUZZARDS CIRCLING IN THERMALS.

THE GLOBALLY VULNERABLE GREATER SPOTTED EAGLE IS A RARE WINTER VISITOR TO SAUDI ARABIA. LARGE BIRDS SUCH AS THIS GENERALLY AVOID FLAPPING FLIGHT ON MIGRATION BECAUSE IT IS SIMPLY TOO ENERGETICALLY EXPENSIVE.

Every day during the autumn migration up to 4,000 Eurasian Buzzards and 500 Steppe Eagles pass through a 10-kilometer stretch of the Tayif escarpment in the northern 'Asir Mountains.

While soaring flight is energetically superior, it is completely dependent on finding suitable updrafts, which only occur during the day. As a result, soaring birds migrate diurnally; they typically begin around mid-morning as thermals develop and soar and glide continuously until convective activity ceases, usually around sunset. To increase their likelihood of finding thermals, soaring migrants often fly in flocks, which allows individual birds to identify the location of thermals in the surrounding airspace: that is, if a soaring migrant sees another bird riding an updraft, it can quickly glide over to the updraft and soar alongside it. One of the great thrills for a birdwatcher in Saudi Arabia is the sight of dozens of migrating Griffon Vultures, Steppe Eagles or Eurasian Buzzards circling overhead in a column of warm rising air.

Significantly, the thermals needed to keep soaring birds aloft occur only over land. As a result, soaring birds often take dramatic detours to avoid flying over large expanses of water. This is fortunate for bird lovers in Saudi Arabia as it brings thousands of soaring birds into the Kingdom each year: rather than crossing the Mediterranean, many soaring birds nesting in Europe take huge detours either west (allowing them to pass across the 14-kilometer-wide Strait of Gibraltar), or to the east, which brings them to the north of the Arabian Peninsula. As an example, satellite tracking of Short-toed Snake-eagle populations nesting in Italy revealed that individuals take land-based detours of up to 1700 kilometers to avoid the 150-kilometer water crossing between Sicily and Tunisia.[18]

The imperative to avoid sea crossings has significant consequences for soaring migrants passing through Arabia, which is bounded in the south, east and west by water too broad for most soaring birds to cross. Soaring migrants must enter the Arabian Peninsula from the north, and leave either through the Bab-al-Mandab Strait in the Red Sea, or the Strait of Hormuz in the Arabian Gulf. As a result, large numbers of soaring migrants are funneled through Saudi Arabia toward these narrow straits.[19]

Soaring migrants frequently aggregate wherever favorable updrafts regularly occur, often along ridgelines and cliff faces – as anyone who has gazed in awe at the dozens of Griffon Vultures gliding serenely past the cliffs at Tanumah in the 'Asir Province will fondly attest. Soaring birds will also funnel through low passes in mountain ranges – like a "traffic jam" of birds attempting to fly through a narrow corridor in the sky. Every day during the autumn migration up to 4,000 Eurasian Buzzards and 500 Steppe Eagles pass through a 10-kilometer stretch of the Tayif escarpment in the northern 'Asir Mountains.[20] Since soaring migrants often follow defined and narrow flight paths, it is clearly vital that these important routes are not modified in any way that might negatively impact the great concentrations of birds that rely upon them.

SHORT-TOED SNAKE-EAGLES WILL TAKE DETOURS OF UP TO 1,700 KM TO AVOID FLYING OVER SEAS OR OCEANS.

A MIGRATORY COMMON SNIPE RESTORES ITS LOST BODY MASS AT A WETLAND IN JUBAIL.

THE CHALLENGES OF MIGRATING ACROSS SAUDI ARABIA

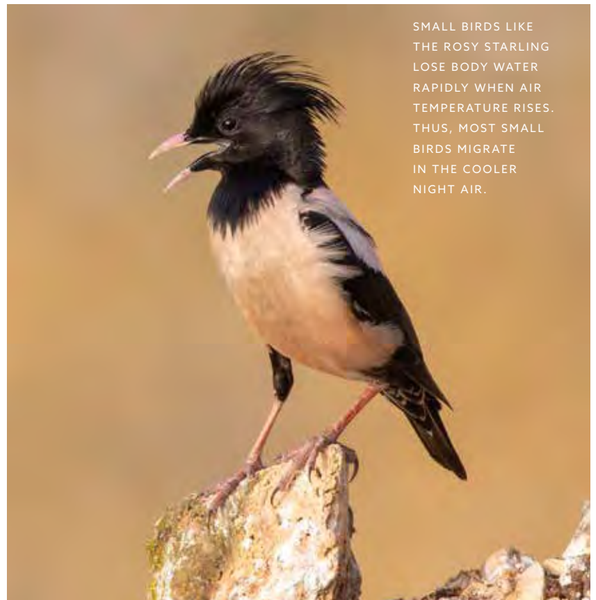
Birds migrating east-west across Saudi Arabia have to pass over 1200 kilometers of desert, plus around 400 kilometers of seas. Meanwhile, birds migrating north-south across Arabia cross nearly twice this distance. These birds are faced with some of the most difficult conditions for migration anywhere on earth: there is very little food, water or shelter, and temperatures in spring or autumn can often be high. Birds that are unable to manage their water and fuel stores while migrating across Saudi Arabia will surely die.

OVERCOMING THE HOT, DRY CLIMATE

Much of Saudi Arabia seems like unsuitable habitat for most species migrating from Europe or Asia. Therefore, many people assume that these birds must migrate across the Arabian Desert in non-stop flights. However, the relatively high daily temperatures typical of Saudi Arabia in spring or autumn means that many birds would dehydrate and overheat if they attempted to fly for long periods during the day. Birds in flapping flight have some of the highest metabolic rates recorded in any animal, which results in high body temperature. To shed body heat, flying birds use internal stores of water for evaporative cooling. During flight, they open their beak to expose the moist inner surface and thus promote cooling by both evaporation and convection.

Wind tunnel experiments have shown that under the warm and dry desert conditions typical of Saudi Arabia migratory birds lose considerable water during flight.[21] For example, the rate of water loss by Rosy Starlings in flight increases appreciably once air temperature exceeds 18°C. If air temperature reaches 27°C these small birds lose 2% of their body mass in water every hour and would become dangerously dehydrated within five hours.[22] Indeed, in most wind tunnel experiments, migratory birds simply stop flying once temperatures exceed 25°C. Thus, for most flapping species, migrating across the Kingdom in a multi-day non-stop flight is simply not possible.

Most small or medium-sized migratory birds avoid the Saudi Arabian heat by flying at night when the air is relatively cool, and then rest in shade during the day.



SMALL BIRDS LIKE THE ROSY STARLING LOSE BODY WATER RAPIDLY WHEN AIR TEMPERATURE RISES. THUS, MOST SMALL BIRDS MIGRATE IN THE COOLER NIGHT AIR.

AFTER MIGRATING DURING THE NIGHT, THE LESSER WHITETHROAT FINDS A SHELTERED PLACE TO REST DURING THE DAY TO AVOID THE HOT SAUDI ARABIAN WEATHER.

THE LOVELY WOODCHAT SHRIKE PASSES THROUGH SAUDI ARABIA IN SPRING EN ROUTE FROM AFRICA TO IRAN.

SOME SPECIES MIGRATE AT ALTITUDE TO AVOID FLYING AT HIGH TEMPERATURES. MALLARDS FOR INSTANCE OFTEN FLY AT 6,500 METERS ABOVE SEA LEVEL.

Instead, most small or medium-sized migratory birds avoid the Saudi Arabian heat by flying at night when the air is relatively cool, and then rest in shade during the day. Nocturnal migration usually starts 30–60 minutes after sunset. Most passerines generally come to land just before sunrise, while many waders and water birds may continue flying for a few additional hours in the morning. Nocturnal migration has the added advantage of offering generally still air or laminar (horizontal) airflow compared with the more turbulent air usually experienced over Saudi Arabia during the day. Based on a sample of 64 small and medium-sized birds that migrate through Saudi Arabia using flapping flight, 64% migrate exclusively at night, 17% migrate during both day and night, while only 19% of species migrate primarily during the day.[23]

Some familiar migrants to Saudi Arabia that are known to rest diurnally during desert crossings include Barn Swallow, Western Yellow Wagtail, Woodchat, Common Reed-warbler, Olivaceous Warbler, Chiffchaff, Willow Warbler, Lesser Whitethroat, Spotted Flycatcher and Common Redstart.[24] However, finding them is not easy. They tend to nestle deep within well-shaded and well-ventilated plants, in nooks and crannies in *jabals*, or anywhere else that provides a modicum of respite, where they remain very still until nightfall. For example, in one study in the Sahara Desert, highly trained ornithologists found very few migratory birds during the day when merely walking along straight-line transects. However, when the same ornithologists systematically searched every individual plant, they found more than ten times as many birds in the same landscape.[25] In other words, nocturnal migrants are present in the desert during the day; they are just very good at hiding. There are more birds in the deserts of Saudi Arabia than at first meet the eye.

To further reduce the costs of migration, particularly across hot deserts, many species migrate at high altitudes where the relatively cool and humid air further reduces water loss. Typically, migrating birds will seek a cruising altitude that offers the best balance of temperature, humidity, wind conditions, and air density, usually around 1000–4000 meters above ground level. Some species migrate considerably higher: the Mallard Duck for instance migrates at around 6500 meters, while some unidentified flapping migrants have been detected on radar exploiting jet streams over the Negev Desert up to 9000 meters above ground level.[26]

Flying at high altitude opens up a new set of problems for migrants: the air is thinner, which makes flight more difficult, and oxygen is significantly lower, making vigorous physical activity extremely challenging, as any mountain climber will verify. To compensate, high altitude migrants have a suite of physiological adaptations including larger lungs and specialized hemoglobin to improve the uptake and supply of any available oxygen in the air to maintain brain and pectoral muscle function. Amazingly, birds migrating with flapping flight at such high elevations are sustaining the most metabolically costly form of locomotion at an altitude that could scarcely support life in any other animal.[27]

WORLD RECORD HOLDERS. BAR-TAILED GODWITS HAVE THE EXTRAORDINARY ABILITY TO MIGRATE 12,000 KM IN A SINGLE NON-STOP FLIGHT. HOWEVER BIRDS FLYING OVER SAUDI ARABIA WILL STOP AND REST AT KEY STAGING SITES ALONG THE SHORELINE.

OVERCOMING THE SCARCITY OF FOOD

Another significant challenge of migrating across Saudi Arabia is the fundamental scarcity of suitable food. Even though many birds rest each day on passage through the Kingdom, most do not feed during their daily stopovers (and those that do receive little nutritional benefit).[28] In other words, birds migrating over Saudi Arabia are essentially fasting.

Therefore it is vital that birds prepare to cross the Kingdom by first storing as much energy as they can to fuel their desert crossing. This fuel is often stored in the form of fat, which contains more energy per unit of mass than protein or carbohydrates. In the days and weeks leading up to a desert crossing, birds dramatically elevate their food intake, causing an appreciable increase in body weight.[29] For example, prior to migration the weight of Northern Wheatears increases by 60%, the body mass of Garden Warblers by 95%, while shorebirds more than double their weight in 3–4 weeks. Amazingly, to boost their food processing capacity at fueling sites, migratory birds quickly grow a temporarily larger intestine, gizzard and liver, thereby increasing the rate that they can store fat.[30]

However, as a bird stores more fuel it becomes heavier, which not only reduces flight efficiency and maneuverability, it also increases predation risk.[31] In one study, Blackcaps carrying extra body fat were unable to takeoff rapidly when threatened by a simulated predation event.[32] Thus, long-distance migrants must find the optimal fuel load to power flight without actually impeding it.

As the bird migrates, it slowly burns its stored supply of energy and gradually loses weight. Once the fat stores are depleted, the bird begins to fuel migration by "digesting" (breaking down and metabolizing) its own organs. For example, when Garden Warblers migrate between Africa and Eurasia, they are confronted with either the Arabian or Sahara Desert. While passing these deserts, the leg muscles shrink by 14%, the gizzard by 34%, the kidney by 42%, along with the small intestine (51%), liver (57%), colon (62%), and bile (85%). Even the flight muscles and the heart itself shrink by around 25%. It appears that only the brain and the lungs remain the same size during migration. This not only helps to fuel the long flight across the desert, it helps to make the bird considerably lighter, which significantly improves flight efficiency. Interestingly, the only organs that significantly *increase* during the Garden Warbler's migration over the desert are the testes, which quadruple in weight.[33] This is not surprising when you consider *why* the bird is undertaking such a long and arduous flight: it is, after all, preparing for the breeding season that lies ahead.

Clearly many migratory birds are heavily depleted by the time they reach their stopover sites or final destinations. Such birds need to assimilate energy (that is, digest food, and create and transport fat bodies to specialized fat deposits) as quickly as possible in order to refuel rapidly. Studies of several migratory species (including the Ruff, Grey Plover, Common Greenshank, Ruddy Turnstone, Common Snipe, Common Sandpiper and Thrush Nightingale) reveal that migrating birds at stopover sites assimilate energy considerably faster than any other vertebrate ever measured (including lactating mice in extreme cold, and Tour De France cyclists during peak energy demands), and indeed faster than previously thought theoretically possible.[34]

Migratory birds at stopover sites also need to quickly rebuild their deteriorating internal organs. After their arduous desert crossing migrating Garden Warblers rapidly regrow their organs during a stopover at the Sinai Peninsula: in the space of nine days, the mass of the heart

Prior to migration the body mass of warblers can increase by 95%, while shorebirds more than double their weight in only 3–4 weeks.

A FEMALE EURASIAN BLACKCAP ON PASSAGE THROUGH THE KINGDOM (THE MALE HAS A BLACK CAP, HENCE THE NAME).

COMMON SANDPIPER. WADERS FEEDING AT STOPOVER SITES ASSIMILATE ENERGY FASTER THAN ANY OTHER VERTEBRATE EVER STUDIED.

Common Swifts average 336 kilometers per day during their 11,500-kilometer migration; they can double this speed when crossing the desert.

increases by 19%, the kidneys by 31%, the small intestine by 61%, and the liver by 65%.[35] Similarly, the digestive tract of migrating Blackcaps rebuilds in fewer than five days; during this period Blackcaps compensate for the reduced size of the digestive system by retaining food in the gut longer, thereby doubling the time the gut can extract nutrients.[36]

In short, the long-distant migrant's body is extraordinarily flexible, able to change adaptively before *and during* flight to suit its current and future needs. When a bird is migrating over the deserts of Saudi Arabia and the surrounding seas, it needs to be a highly efficient, lightweight *flying* machine: its beautifully aerodynamic wings are powered by large pectoral muscles, and the digestive tract is diminished. When it arrives at a feeding site, the bird needs to transform rapidly into a highly efficient *eating* machine: the pectoral muscles are reduced, and the digestive system is quickly rebuilt. It is a truly incredible transformation.

By migrating at night and at altitude, and by fasting during migration, small and medium-sized birds are able to fly over Saudi Arabia and its surrounding seas using the most direct possible route. Thus, these smaller species usually migrate on broad fronts (rather than along the narrow corridors typical of the larger, soaring migrants). This brings many small migrants to our gardens, fields and farmlands, including redstarts, stonechats, whitethroats, flycatchers, and many of the warblers. These birds will often stay for a few days or perhaps weeks, replenishing their fuel supply before continuing their journey. Similarly, many of the waders refuel at wetlands, lagoons or intertidal flats. Those precious few lagoons that provide a reliable source of food for waders and shorebirds sometimes receive thousands of migratory birds, and are therefore critical habitat.

RED-RUMPED SWALLOW. SWALLOWS, MARTINS, SWIFTS AND BEE-EATERS ALL CATCH THEIR INSECT PREY IN FLIGHT WHILE MIGRATING OVER SAUDI ARABIA.

THE NORTHERN HOUSE MARTIN FORAGES FOR FLYING INSECTS WHILE MIGRATING ACROSS THE KINGDOM.

As mentioned above, around 19% of Saudi Arabia's small flapping migrants migrate diurnally. Most of these species have something in common – they actively forage while migrating. For example, martins, swallows, swifts and bee-eaters all migrate at low altitudes during the day (and sometimes at night), foraging on aerial insects. These small birds switch instantaneously between flapping and soaring flight, immediately soaring in response to tiny updrafts, which reduces the costs of migration. The ability to actively forage while flying allows these species to migrate at very fast speeds across the desert. Geolocators fitted to Common Swifts reveal that these petite birds pass directly over immense deserts without stopping. In fact they often fly faster over deserts, probably in response to reduced aerial insect activity and increased diurnal temperature: while Common Swifts average 336 kilometers per day during their 11,500- kilometer migration, they can double this speed when crossing a desert.[37]

Many seabirds, including the Osprey, terns and gulls, also forage while migrating diurnally. Satellite telemetry reveals that rather than following a direct route over land, Lesser Black-backed Gulls and other feeding generalists tend to follow coastlines that provide a relatively dependable source of food. They stop frequently on travel days to forage, and will also pause for several days at a time at particularly rich foraging areas, meaning their total migration speed (43–98 kilometers per day in autumn and spring, respectively) is one of the slowest reported for birds.[38]

Some small falcons and sparrowhawks also migrate during the day. These birds forage diurnally, often preying on other diurnal migrants. They also hunt resident birds, such as doves and pigeons. Consequently, it is not uncommon to see migrating falcons and sparrowhawks in the towns and cities of Saudi Arabia looking to make a quick meal out of an unsuspecting dove.

OSPREY HUNT FOR FISH WHILE MIGRATING ALONG THE COASTS OF SAUDI ARABIA.

The Northern Wheatear has the longest migration of any songbird in the world, and it passes right through Saudi Arabia.

OVERCOMING THE LACK OF BREEDING SITES

One of the major challenges facing any migratory bird is the limited number of breeding spaces available at the breeding grounds. This means that birds literally race across the world in an effort to get to the breeding grounds first so that they can find the best territories and the best mates. In this section, we discuss case studies for two species (Northern Wheatears and Great Reed-warblers) that typify the extraordinary efforts migratory birds go through in order to breed.

CASE STUDY 1: NORTHERN WHEATEARS, RACING AGAINST TIME

The Northern Wheatear is a classic example of just how amazing birds can be. This unassuming bird has the longest migration of any songbird in the world, and it passes right through Saudi Arabia. It also has one of the largest breeding ranges of any songbird, breeding from eastern Canada, across Greenland, Iceland, northern Eurasia, to Alaska and northwest Canada. However, wheatears spend only around 87 days at their arctic breeding grounds; they have to quickly vacate their nesting sites before winter arrives. As the days shorten, wheatears undertake a journey to warmer climes – a journey that almost defies belief.

Using miniature geolocators fitted to individual wheatears, scientists have demonstrated that the Siberian and Alaskan populations travel an astonishing 15,000 kilometers southwest over the Bering Strait, across all of Asia, through Saudi Arabia, and into East Africa for the winter. The Alaskan birds travel this astounding distance in 91 days, averaging 160 kilometers per day.[39] In other words, by the time the birds arrive in Saudi Arabia around October–November they have already

ONE OF THE WORLD'S MOST EXTRAORDINARY MIGRANTS, THE NORTHERN WHEATEAR RESTS IN SAUDI ARABIA DURING ITS 30,000 KM ROUND TRIP.

LURKING THROUGH REED BEDS, THE COMMON LITTLE BITTERN IS THE MORTAL ENEMY OF THE GREAT REED-WARBLER.

Northern Wheatears migrate up to 30,000 kilometers per year, and yet these unassuming birds weigh only 25 grams – about as much as a slice of bread.

been travelling for around 80 days, and they still have another 10 days left until they reach their destination. Remarkably, these unassuming birds weigh only 25 grams – about as much as a slice of bread. Scaled for body size, this is the one of the longest migratory journeys of any bird in the world – and yet their grueling annual migration is only half complete.

These little birds spend around four or five months in Africa searching for invertebrates. Then, sometime between 29 March and 8 April, they begin the arduous return migration back to their distant breeding grounds thousands of kilometers away. This time, however, the migration is even more breathtaking, because this time it is a race.

For most migratory species the return journey to the breeding grounds is a race because breeding space is limited: there is simply not enough high quality breeding territories to enable every bird to reproduce every year. Much like a game of "Musical Chairs", migration is effectively a competition to see which birds can arrive at the breeding grounds early enough to secure one of these precious territories.

Male Northern Wheatears that arrive at the breeding grounds early are able to find the best territories that are safe from predation and contain all the food needed to raise healthy offspring. Females begin to arrive about 7–15 days after the males and pair up with males holding the prime sites. Thus, males that arrive early are more able to attract a female and together they have sufficient food to produce healthy young.[40]

The challenge to find vacant and safe breeding sites can have a remarkable impact on migratory and breeding behavior, as exemplified by the Great Reed-warbler.

In contrast, those males that arrive at the breeding grounds just a few days later find all the best territories have already been taken; they have to settle for suboptimal territories that contain less food. They tend to pair with females that also arrived late. These females now have a few less days to produce young before the winter chill sets in. Because they have less time to rest before laying their eggs, they lay fewer eggs, and each egg is smaller. Accordingly, their offspring tend to be less healthy and are less likely to survive to adulthood.[41]

Finally, those males that arrive around 7–14 days late usually fail to breed altogether. These males tend to be the younger, less fit birds. In any given year between 5–26% of males miss out on breeding.[42] In other words, for up to one quarter of males, the 30,000-kilometer round trip to Alaska and back was a waste of time and energy.

This competition for limited breeding territories means that the spring migration towards the nesting grounds occurs at breakneck speed: most Alaskan Northern Wheatears fly the 15,000-kilometer journey in only 46–56 days, covering an average of 290 kilometers per day. In other words, the race for nest sites means that birds migrate almost twice as fast towards their breeding grounds compared to the autumn migration towards their African wintering grounds where there is less pressure to arrive early.[43]

Only birds in good condition are able to survive the costs associated with migrating quickly across such vast distances. Each bird must carefully manage its energy reserves as it travels along the migration route: birds that migrate too quickly will die from exhaustion; birds that migrate too slowly will fail to breed.

Each individual bird typically migrates overnight in seven-hour "hops" before resting and refueling during the day, often for several days in a row, before embarking on the next leg of their remarkable journey. During an average migration wheatears actually spend around 80% of their time at stopover sites, and only 20% of their time actively flying.[44]

Each night every individual bird decides whether to set off on the next seven-hour marathon or whether to spend another day refueling. Birds make these departure decisions based on external factors, such as wind direction and weather conditions,[45] and internal factors, particularly hunger. Birds that have been able to forage efficiently at the stopover site set off earlier in the evening and fly for longer durations during the night, giving them a distinct advantage in the race to acquire a breeding site. In contrast, weaker individuals typically start their journey later in the night and fly shorter distances, moving from one suboptimal foraging patch to another.[46] In other words, migrating individuals that find themselves in poor condition tend to fall further behind in the race to acquire a breeding site. Unless they find a rich food source soon, they will not make it to the breeding grounds in time – or at all. Once again it is essential that stopover sites within the Kingdom are protected to enable these amazing birds to survive their magnificent journeys.

CASE STUDY 2: GREAT REED-WARBLERS, LIVING IN HAREMS

The challenge to find vacant and safe breeding sites can have a remarkable impact on migratory and breeding behavior, as exemplified by the Great Reed-warbler. These birds spend the winter in tropical Africa before migrating to Arabia, Asia and Europe where they nest in reedbeds around

MORE THAN 30% OF WESTERN MARSH-HARRIERS DIE DURING THEIR FIRST MIGRATION, PARTICULARLY IF THEY CANNOT CATCH ENOUGH PREY.

wetlands. Once again, because there are limited nesting spaces within each reedbed there is competition for the best territories. The fittest males arrive at the breeding grounds first and quickly secure and defend the highest quality nesting territories, which contain stronger, denser vegetation, such as a shrub amongst the reeds, and those in deeper water, farther from shore. These territories are preferred because they are safer from predators, particularly the Western Marsh-harrier and the Common Little Bittern, which are the Great Reed-warbler's mortal enemies. To defend his territory the male chases other birds and sings short, simple, quiet songs to make sure rival males know the territory is taken. Most of the poorer quality males that arrive late manage to establish a poor quality territory amongst thin reeds with little protection from predators.

In some Great Reed-warbler populations up to 80% of males maintain a harem.

Once they have established their territory, the males try to attract a female by singing loud, long and variable songs. The complexity and quality of the song is a direct reflection of male quality. Certain elements in the male's song advertise his familiarity with the breeding grounds, which indicates he has successfully avoided predation for several years. Males with a large song repertoire

AFTER MIGRATING FROM SOUTHERN AFRICA, GREAT REED-WARBLERS NEST IN WETLANDS IN SAUDI ARABIA, FORMING HAREMS OF UP TO FOUR FEMALES.

are able to secure and defend higher quality territories and are therefore very attractive to females.[47]

The females that arrive at the breeding grounds first choose to pair up with the fittest males in the highest quality territories. Radio-tracking studies show that each female typically visits at least six males (listening to their songs and assessing their territories) before choosing where to build her nest. Nesting in a high quality territory ensures that both the female and her nestlings will be relatively safe from predators and cuckoos. It also ensures that her offspring will inherit their father's good genes making them more likely to survive and to breed.[48]

But what happens to the females that arrive late when all of the higher quality males have already paired with other females? These females are faced with a choice: they can nest with one of the poor quality, unmated males living in the worst, most dangerous territories, or they can choose to nest with a high quality male that has already paired with another female. That is, the female can choose to form a polygynous harem.

The proportion of polygynous nests varies from site to site and from year to year, but is often around 40% of nests in a population. In some populations up to 80% of males maintain a harem.

AN ORIENTAL HONEY-BUZZARD MIGRATES TO SAUDI ARABIA WHERE IT WILL SPEND THE WINTER.

Often multiple females will choose to nest with the highest quality males in the very best and safest territories. For example, some males have up to five females nesting simultaneously on their territories. In contrast, about 20% of the poor quality territorial males remain unpaired for the season. Male song complexity is correlated with harem size, so if you hear a Great Reed-warbler singing a wide range of songs, he probably has many females nesting in his high quality territory.[49]

In Great Reed-warblers only the female incubates the eggs, while both parents feed and care for the chicks. Interestingly, the male living in a harem provides much more food to the nest that hatches first on his territory; in contrast, he provides less food and smaller prey items to the chicks at the "secondary nests" on his territory. Therefore, the "secondary females" have to work harder and bring more prey items to the nest to ensure their chicks receive enough food to survive. The male also defends his primary nest far more vigorously than his secondary nests. In other words, there are clear costs of being a secondary female in a harem in Great Reed-warblers. Nonetheless the significantly lower rate of predation at high quality territories compensates the secondary females for the extra work she has to do to overcome the lack of help from the male.[50]

Now here is where things get really interesting. Because the male helps most at the nest that hatches first, the secondary females often deliberately destroy the eggs of the primary female in the territory. By doing so, she ensures that *her* eggs hatch first; that is, *she* becomes the primary female, thereby enticing the male to bring more food to her young. In turn, this means that she will be able to rest a little bit more during the chick-feeding phase, which probably allows her to live longer and to produce more offspring in her next breeding attempt.[51]

At the end of the breeding season, Great Reed-warblers commence their return migration to tropical Africa. On average, only about 55% of adults and only 16% of chicks will return to the same wetland for the next year's breeding season where they will again sing for the right to nest in the highest quality territory.

THE COSTS OF MIGRATION

Despite the impressive array of adaptations for long distance flight, migration across ecological barriers such as the deserts, mountains and seas of Saudi Arabia is nonetheless a costly activity for most birds. Surely the clearest demonstration of this is the dramatic spike in mortality experienced by many species during the migratory season, even in soaring migrants. A recent satellite telemetry study of Osprey, Western Marsh-harrier and Montagu's Harrier revealed that daily mortality rate is six times higher during migration than during either the winter or breeding seasons. For each species, half of all mortality occurs during the 10-week migration. Indeed, Ospreys are almost twice as likely to die during their 26-day spring migration as they are during the 294 days spent in their summer or winter ranges.[52]

Mortality on migration is particularly high amongst juveniles. In another satellite telemetry study, 31% of juvenile Osprey, Western Marsh-harrier, European Honey-buzzard and Eurasian Hobby died attempting their first desert crossing, presumably because juvenile raptors are inexperienced, less resilient and more vulnerable to weather conditions.[53] Elevated mortality has also been observed in migrating Eurasian Spoonbills, especially amongst spring migrants attempting to fly over desert areas.[54] Mortality during migration may be even higher for flapping migrants: in one study, songbird mortality was 15 times higher during migration than at any other time of year;[55] in another, only 12% of Sooty Falcons breeding in Oman survived to the average age of first breeding (3.8 years), with most mortality occurring during the first migration.[56]

Only 12% of Sooty Falcons breeding in Oman survive to adulthood, with most mortality occurring during the first migration.

Sadly, in today's world one of the biggest threats to a migrating bird on its miraculous journey is illegal hunting. A recent study calculated that around 3.2 million individual birds are killed illegally in the Arabian Peninsula, Iran and Iraq each year.[57] At least 800,000 migratory birds are killed *every year* in Saudi Arabia alone. What's more, since the study was unable to survey many parts of the Kingdom, that figure is likely to be a significant underestimate of the total number of birds killed illegally in Saudi Arabia each year. How terribly tragic. Such levels of hunting are unsustainable and are leading to noticeable declines in bird numbers in the Kingdom.

CONCLUSION

When we see migratory birds flying through Saudi Arabia, be they tiny warblers or wheatears or cruising leviathans like eagles and vultures, let's appreciate them for what they are: extraordinary athletes, expert navigators, and finely-tuned tight-rope walkers living on the edge of exhaustion in a quest to produce offspring. Clearly it is vital that we allow these visiting dignitaries free passage through Saudi Arabia and support them by keeping their precious foraging areas intact.

CHAPTER 6

The Extraordinary Lives of Arabia's Endemic Birds

ARABIAN SUNBIRD

KEY POINTS

- Saudi Arabia is very fortunate to contain 15 bird species that are endemic to the Arabian Peninsula (that is, their global population is restricted to the Arabian Peninsula) as well as four species that are very nearly endemic.
- One species – the Asir Magpie – is entirely restricted to Saudi Arabia, occurring in a few small patches of forest in the 'Asir Mountains and nowhere else on earth. It is one of the most endangered birds on the planet.
- Endemic birds are particularly important because they help to make Saudi Arabia unique.
- A large percentage of the world's population of each of these species occurs in Saudi Arabia, meaning that the Kingdom has an important role to play in their conservation.
- Very little or no study has been conducted on most of the Arabian endemic species. They are goldmines just waiting to be discovered, celebrated and cherished.

SEVERAL ARABIAN POPULATIONS ONCE THOUGHT TO BE THE SAME AS AFRICAN OR EURASIAN BIRDS ARE IN FACT DISTINCT SPECIES ENDEMIC TO ARABIA, SUCH AS THE ARABIAN GREEN BEE-EATER.

ARABIA'S ENIGMATIC ENDEMIC BIRDS

Saudi Arabia is indeed privileged to have 15 wonderful bird species that are endemic to the Arabian Peninsula; that is, they occur in the Arabian Peninsula and nowhere else on earth. One of these species, the Asir Magpie, is endemic to the Kingdom. In other words, the global population of this rare bird occurs entirely within Saudi Arabia. The Kingdom also hosts four species that are very nearly endemic to the region, with more than 98% of their global populations breeding in the Arabian Peninsula (*see* Table 1). In addition, 37 species have at least one subspecies that is endemic or nearly endemic to the region. Thus, around one in 10 bird species within the Kingdom have populations that are found only in Arabia.

Endemic species are particularly important because these birds help to make the Kingdom unique and because Saudi Arabia has an important role to play in conserving them. Fortunately only 10.5% (2 out of 19) of the Arabian endemic species that occur in the Kingdom are currently listed as threatened with extinction, which is less than the global average (14.6%), while four other species are listed as near threatened. Unfortunately 37% (7 out of 19) of Saudi Arabia's endemic species are decreasing, including all of the threatened and near threatened endemics (*see* Table 1). The key threatening process in each case is habitat fragmentation caused by urban and agricultural expansion. Conversely, all 10 of the endemic species that are listed as stable or increasing are species that are able to directly exploit agricultural areas or can tolerate human settlements.

THE ENDEMIC ARABIAN WOODPECKER. UNFORTUNATELY THERE HAVE BEEN VERY FEW STUDIES CONDUCTED ON THE ENDEMIC BIRDS OF ARABIA.

Previously, the number of regional endemic species occurring in Saudi Arabia was thought to be lower.[1] However, recent focus on the birds of Arabia has shown that several Arabian populations once thought to belong to the same species as African or Eurasian populations are in fact distinct species unique to Arabia. Thus Arabian populations of what were previously considered as Green Bee-eater, Dunn's Lark, Shining Sunbird, Isabelline

THE ARABIAN WHEATEAR WAS PREVIOUSLY REGARDED AS AN ENDEMIC SPECIES, BUT IS NOW LUMPED WITH THE MOURNING WHEATEAR, WHICH OCCURS FROM NORTHERN AFRICA EAST TO IRAN.

DESPITE ITS NAME, THE ARABIAN GOLDEN SPARROW IS NOT CONFINED TO THE ARABIAN PENINSULA AND THEREFORE IT IS NOT AN ENDEMIC SPECIES.

Wheatear and Eurasian Magpie are now regarded as endemic or near endemic species today known as the Arabian Green Bee-eater, Arabian Lark, Arabian Sunbird, Buff-breasted Wheatear and Asir Magpie, respectively. Conversely, one bird that was previously regarded as an endemic species (the Arabian Wheatear) has recently been downgraded to being a subspecies of the Mourning Wheatear, which occurs patchily in northern and eastern Africa and across Arabia to Iran.[2]

This chapter describes the remarkable lives of the 19 regionally endemic and near endemic species breeding in Saudi Arabia, as well as one population (Arabian Spotted Eagle-owl) that is likely to be elevated to a distinct Arabian endemic species in the near future. It begins with Saudi Arabia's only nationally endemic species, the Asir Magpie, followed by the 14 other Arabian endemic species, the four near endemic species, and ends with the probable endemic species (*see* Table 1). This chapter highlights the many gaps in our knowledge of Arabia's enigmatic endemic birds in the hope that it will inspire researchers to study the untold secrets of the extraordinary lives of Arabian birds.

TABLE 1: CONSERVATION STATUS OF REGIONALLY ENDEMIC BIRDS OCCURRING IN SAUDI ARABIA

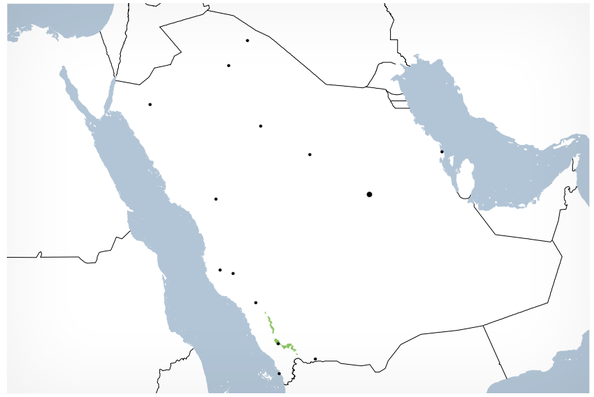
SPECIES	SAUDI ARABIAN POPULATION SIZE (ESTIMATED BREEDING PAIRS)	GLOBAL POPULATION SIZE (ESTIMATED BREEDING PAIRS)	% OF GLOBAL POPULATION BREEDING IN SAUDI ARABIA	CONSERVATION STATUS	POPULATION TREND
SPECIES THAT ARE ENDEMIC TO SAUDI ARABIA					
ASIR MAGPIE	100	100	100	ENDANGERED	DECREASING
SPECIES THAT ARE ENDEMIC TO THE ARABIAN PENINSULA					
PHILBY'S PARTRIDGE	15,000	25,000	60	LEAST CONCERN	STABLE
ARABIAN PARTRIDGE	150,000	400,000	38	LEAST CONCERN	STABLE
SOCOTRA CORMORANT	35,000	110,000	32	VULNERABLE	DECREASING
ARABIAN SCOPS-OWL	14,000	30,000	47	LEAST CONCERN	STABLE
ARABIAN WOODPECKER	5,500	7,500	73	NEAR THREATENED	DECREASING
YEMEN WARBLER	5,000	9,000	56	NEAR THREATENED	DECREASING
YEMEN THRUSH	5,000	10,000	50	NEAR THREATENED	DECREASING
BUFF-BREASTED WHEATEAR	13,000	40,000	33	LEAST CONCERN	STABLE
ARABIAN SUNBIRD	250,000	500,000	50	LEAST CONCERN	STABLE
ARABIAN WAXBILL	5,000	30,000	17	LEAST CONCERN	DECREASING
ARABIAN GROSBEAK	500	3,000	20	NEAR THREATENED	DECREASING
ARABIAN SERIN	260,000	400,000	65	LEAST CONCERN	STABLE
YEMEN SERIN	25,000	100,000	25	LEAST CONCERN	STABLE
YEMEN LINNET	100,000	200,000	50	LEAST CONCERN	STABLE
SPECIES THAT ARE NEARLY ENDEMIC TO THE ARABIAN PENINSULA					
ARABIAN GREEN BEE-EATER	75,000	150,000	50	LEAST CONCERN	INCREASING
ARABIAN LARK	17,000	20,000	85	LEAST CONCERN	STABLE
ARABIAN BABBLER	75,000	150,0002	50	LEAST CONCERN	INCREASING
TRISTRAM'S STARLING	35,000	100,000	35	LEAST CONCERN	STABLE
SPECIES THAT ARE PROBABLY ENDEMIC TO THE ARABIAN PENINSULA					
(ARABIAN) SPOTTED EAGLE-OWL	800	2,000	40	LEAST CONCERN	STABLE

ASIR MAGPIE (*PICA ASIRENSIS*)

The Asir Magpie is one of the rarest birds in the world. Latest estimates suggest that only 50–100 breeding pairs are left, equating to around 270 adult birds. This is by far the smallest population of any endemic bird in the Arabian Peninsula. The entire global population occurs only in small patches of juniper forest in the southwest highlands of Saudi Arabia *and nowhere else on earth*. Not only is this endemic bird rare, it is becoming even rarer, and is headed toward extinction.

When Western scientists first discovered magpies in Saudi Arabia in 1936, they assumed these charismatic birds were simply an isolated population of the familiar Eurasian Magpie (*Pica pica*) that occurs across virtually all of Europe and much of temperate Asia. Thus, for decades the Saudi Arabian population of magpies was regarded merely as a subspecies of Eurasian Magpie and given the scientific name *Pica pica asirensis*.[3] However, with further observations some authorities began to suggest that the Saudi Arabian magpies were sufficiently different to be regarded as a distinct species.[4] Accordingly, in 2016 – some 80 years after its initial discovery – the Asir Magpie was formally recognized as a separate species by BirdLife International and is now known scientifically as *Pica asirensis*.[5]

There are four main reasons for defining the Asir Magpie as a separate species to the Eurasian Magpie. First, the Saudi Arabian population of magpies is the most geographically isolated magpie population on earth. In fact the population of magpies living in the 'Asir Mountains is at least 1,200 kilometers from the nearest population of Eurasian Magpie. Second, and as a result of this isolation, the Asir Magpie has become morphologically distinct from the Eurasian Magpie. Compared to the Eurasian Magpie, the Asir Magpie is darker and duller overall, with more black in the plumage (it has an entirely black rump, a narrower white patch on the scapular, and less extensive white in the primaries), and more purple-green in the tail. It also has shorter wings, a much shorter tail, larger, stronger feet and a considerably larger bill. Third, the Asir Magpie is noticeably more vocal than the Eurasian Magpie and with quite different calls, particularly the contact call, which it uses constantly when moving around in its foraging groups.[6]



ASIR MAGPIE: ENDEMIC TO SAUDI ARABIA.

The Asir Magpie is one of the rarest birds in the world – and it is becoming rarer with each passing year.

THE ASIR MAGPIE IS LARGELY CONFINED TO A TINY AREA HIGH IN THE 'ASIR MOUNTAINS BETWEEN AN-NAMAS AND BILLASMAR ONLY 37 KM TO THE SOUTH.

The Asir Magpie is an ancient population that has been living in isolation in the 'Asir Mountains for over 1.4 million years – but now it is on the brink of extinction.

Magpies are among the most intelligent birds on earth with the ability to recognize themselves in a mirror and the capacity to learn abstract concepts at a greater level than exhibited in some primates.

Magpies regularly store food, either on trees or buried in the ground, which they relocate days or weeks later using their impressive sense of smell and their equally impressive memory.

Finally, recent molecular analyses using mitochondrial DNA indicate that the Asir Magpie is indeed genetically distinct from all other magpies, and deserves its status as a full species.[7]

These recent genetic studies indicate that the Asir Magpie is most closely related to magpies from the Qinghai-Tibet Plateau in southwestern China. It appears that over 3 million years ago, magpies occurred across Arabia northwest into northern Africa and northeast into Tibet when the Saharo-Arabian region was covered by vast areas of grassland savanna. However, with periods of desertification of varying intensity, the magpie population became increasingly fragmented. The Arabian population eventually separated from the Tibetan population over 1.4 million years ago and has gradually adapted to the 'Asir environment to become a distinct species.[8] In other words, the Asir Magpie is an ancient population that has been living in isolation in the 'Asir Mountains for over 1.4 million years – but now it is on the brink of extinction.

The Asir Magpie belongs to the crow family (known more formally as the Corvidae), which contains 123 species, including five species of *Pica* magpies: the widespread Eurasian Magpie mentioned above, the Maghreb Magpie (*P. mauritanica*) of northern Africa, the Yellow-billed Magpie (*P. nutalli*) of California USA, the Black-billed Magpie (*P. hudsonia*) of eastern North America, and of course the Asir Magpie of Saudi Arabia. Of these five species, the Asir Magpie is by far the least studied and by far the most endangered.

Numerous studies have shown that magpies are among the most intelligent birds on earth, with a large forebrain to hindbrain ratio that confers them with problem solving abilities, innovation, and in some cases tool-making abilities. Experimental research has demonstrated that magpies have the capacity to learn abstract concepts at a greater level than exhibited in some primates;[9] they can hide food items for long periods and then remember where, when and what food items they hid;[10] they can identify individual humans and remember which individuals have previously threatened their nest;[11] they even have the ability to recognize themselves in a mirror, which had never before been demonstrated in non-mammalian species.[12] These are truly exceptional birds.

HABITAT

The Asir Magpie is largely confined to a tiny area high in the 'Asir Mountains between an-Namas and Billasmar only 37 kilometers to the south. It is also occasionally recorded near Abha. It is recorded generally above 2,100 m, though it sometimes found down to 1,950 m. This is the most temperate region of Saudi Arabia. The temperature varies from -3°C in winter to only 34°C in summer and with a mean annual rainfall of 177 millimeters, it is the wettest place in the Kingdom. It prefers thick, shady juniper forest on the cooler, south facing slopes of densely vegetated upland valleys and wadis. The fact that it has been recorded more often on south facing slopes is interesting as these slopes receive more rainfall and more mist. Thus, this rare bird appears to have contracted to the last remaining moist area in Saudi Arabia. It occasionally occurs in cultivated areas and open hillsides with scattered junipers, acacias and broad-leaved trees. It tends to avoid human sites.[13] It roosts in trees in well-vegetated areas, such as wadis, generally in the same area each night.

FORAGING ECOLOGY

The brief recorded observations of the Asir Magpie indicate that its foraging ecology shares several features in common with that of the Eurasian Magpie, Yellow-billed Magpie and Black-billed Magpie, which have been studied in detail. All of these species are omnivorous and opportunistic, taking whatever is locally available, including a wide array of invertebrates (such as beetles, grasshoppers, butterflies and moths, bees, ants and wasps, true bugs, and flies), carrion (especially road kill), plant material (including a variety of berries, fruits, seeds and nuts), and human food scraps. The Asir Magpie has been recorded feeding on juniper berries, fruiting figs, boiled rice from picnic sites, fallen grain and road-kill.[14]

If Asir Magpies do indeed have a similar diet to the other well-studied magpies, then Asir Magpies are likely to also occasionally prey on the eggs and nestlings of other birds, and may sometimes hunt small birds (such as sparrows) in flight. They are also likely to eat whatever small mammals, lizards and amphibians they are able to catch.[15] Other magpie species regularly store food, either on trees or buried in the ground, which they relocate days or weeks later using their impressive sense of smell and their equally impressive memory (thanks to an enlarged hippocampus, which is the area of the brain associated with spatial memory).[16]

Asir Magpies are rarely seen alone. Instead they live in small family groups of usually 5–7 individuals that forage together, moving ceaselessly (and calling incessantly) from dawn to dusk usually within 2–3 kilometers of their roost-site.[17] They feed almost entirely on the ground, digging into soil and litter, or flipping over scraps of rubbish. Sadly, they can also be seen foraging inside rubbish containers.[18]

BREEDING BIOLOGY

Like all magpies, Asir Magpie family groups appear to be sedentary and territorial, often nesting in the same territory for at least several years in a row. The nest of the Asir Magpie is typical of the genus: that is, a large, oval-shaped mass (around 50 x 60 centimeters) of loosely arranged dry sticks and twigs with a thick nest cup in the center made of mud. The mud nest cup is lined with feathers, slender twigs and rootlets. A thick dome of twigs is built above the nest cup. Birds enter the nest through an entrance in the side that leads to the mud cup. Nests are built around 3–8 m above ground at the base of a fork in a juniper tree or occasionally in acacia.[19] Although these sturdy nests often last for several years, new nests are built annually, often very close to nests from previous seasons. As a result, many old nests can be found in close proximity to one another, presumably around the center of the territory.

Apart from these observations of the general appearance and structure of the nest, surprisingly little has been reported about the breeding biology of this endemic and relatively easily observed species. However, the nesting behavior of well-studied magpies all converge upon fairly similar traits. If the Asir Magpie follows suit, then we can expect Asir Magpies to form long-term socially monogamous pairs. Both sexes may pursue extra pair copulations, and hence the male will try to guard the female by staying close to her prior to egg laying.[20]

In other magpies, the male collects the majority of the nest material, which the female then uses to actually build and shape the nest. It takes from 1–8 weeks to build the bulky nest, with more experienced pairs completing the nest more rapidly. Such large, complex nests are energetically costly to build. In fact, Black-billed Magpies conduct over 2,500 trips and fly at least 276 kilometers to collect material and build a nest that ultimately weighs up to 70 times more than the bird itself.[21]

Interestingly, in Eurasian Magpies the female assesses male quality based on the amount of nest material he provides and the time he takes to provide it. The female then adjusts her clutch size to match the amount of effort the male exerted in nest building: that is, if a male brought enough material to build a large nest then the female will not only lay more eggs, she will also lay larger eggs.[22] In this way the female aligns her reproductive effort to her partner's quality and his apparent willingness to invest in reproduction.[23]

All species of magpie lay a single, large clutch, varying from around 2–10 eggs, with most nests

In order to make a nest, each magpie must conduct over 2,500 trips and fly at least 276 kilometers to collect the material it needs to builds a structure that ultimately weighs 70 times more than the bird itself.

THE ASIR MAGPIE FEEDS ALMOST ENTIRELY ON THE GROUND.

THE BULKY STICK NEST OF THE ASIR MAGPIE SILHOUETTED AGAINST THE TANUMAH SKY.

containing 5–7 eggs. Incubation takes from 16–22 days. The female performs all incubation while the male brings food to her at the nest. A magpie's clutch hatches over several days, meaning there is a significant size difference between the first and last hatchlings. Interestingly, although magpies usually lay 5–7 eggs, typically only 2–4 chicks survive to fledging. The later hatchlings generally die of starvation within a few days of emerging from the egg because the parents do not bring them sufficient food.[24] Why do female magpies lay so many eggs when more than half of them die of starvation in the nest? Experimental studies on magpies indicate that laying excess eggs is an optimistic strategy: that is, if environmental conditions improve during the incubation period and there is a sudden abundance of food in the territory, then the parents will be able to bring sufficient food to raise the entire clutch. However, if conditions do not improve during the incubation period, the parents simply allow the smaller, younger chicks to die.[25] Preliminary observations of Asir Magpies suggest that like other magpies, they too usually fledge around 2–5 young. While it is not known how many eggs are laid, it is likely that Asir Magpies engage in the typical magpie strategy of brood reduction to match their brood size to current environmental conditions.

The global population of Asir Magpies is estimated at only 50–100 breeding pairs. This tiny population occurs in fragmented, isolated pockets in the mountains of southwest Saudi Arabia – and nowhere else on earth.

Observations of Asir Magpies indicate that both sexes feed and tend the nestlings. Magpie nestlings beg loudly and emphatically for food, which places the nest at significant risk of predation (as demonstrated experimentally in Eurasian Magpies) and may thus encourage adults to feed them more often.[26] In other words, the adults must feed the chicks often, or else they will attract predators with their loud begging.

Both parents actively defend the nest, chasing off intruders and alarm calling with a repeated "*ack ack ack ack*" call. Indeed, this call is so familiar that many local people simply call this bird "Ack Ack". Nesting birds will sometimes display to intruders by breaking off twigs of juniper trees with their beak and tossing them away vigorously, apparently as a show of strength.[27] In other magpies, the chicks fledge around 30 days after hatching, and both parents continue to feed the young for a further 3–8 weeks.

Some of the young do not disperse after achieving foraging independence. Instead they appear to spend a year or more in the natal territory where they form a family group (well documented in Eurasian Magpies: Eden 1987). However, unlike some species that live in long-term family groups (such as Arabian Babblers), the young birds do not appear to help during subsequent nesting attempts, for example by bringing food items to their younger siblings. Those that do disperse tend to establish a territory only 400 m from their parents.[28]

Long-term detailed studies of Asir Magpies are needed to determine whether these exclusively Saudi birds share these fascinating traits with other magpies, and to identify any additional unique adaptations for life in the highlands of Saudi Arabia.

CONSERVATION STATUS

The global population of Asir Magpies is estimated at only 100 breeding pairs. Some authorities have suggested that even this grim estimate may be optimistic.[29] Indeed, it may be as low as 50 pairs.[30] This tiny population occurs in fragmented, isolated pockets in the mountains of southwest Saudi Arabia (*see* Table 1). Accordingly, the IUCN lists the Asir Magpie as endangered. What's more, this small remnant population is decreasing further.

Although there have been no formal surveys of Asir Magpies, anecdotal reports suggest both the distribution and abundance of this species has noticeably decreased over the last few decades. When the bird was first recorded in 1936, it was regarded as "quite plentiful in the juniper forests" near Abha, and was even observed "outside [the] juniper zone in [a] valley of plentiful acacias".[31] Early surveys found the Asir Magpie as far north as Tayif. However, by 1996 observers began to report that the Asir Magpie's "population and distribution may have suffered a decline throughout its range in recent years".[32] Likewise, a thorough survey of the 'Asir in 2010 again noted "this very scarce bird has declined further in numbers in recent years".[33] Sadly, this decline seems to have continued in the period from 2010 to 2016. For example, in five surveys between February 1995 and July 1996, 147 sightings were recorded in the area between Abha and 120 kilometers north of Abha as well as Jabal Gaha.[34] That amounts to almost 30 sightings of Asir Magpies per visit. However, since 2010 there have been no more than 10 sightings per visit during any single survey despite multiple visits to the same area by several highly skilled bird watchers and photographers.[35]

Asir Magpies seem to have all but disappeared from several well-known strongholds for the species, such as Rayda Reserve, Jabal Sawda', Jabal Aswad, Jabal Gaha, and Wadi Tale'a.[36] The species has not been seen north of an-Namas since 2010, which suggests its northern limit has retreated from Tayif to an-Namas, a contraction of over 295 kilometers or more than 85% of its range. Since 2010, the only area where Asir Magpies are regularly seen is the 37-kilometer stretch of mountains between Billasmar and an-Namas on either side of Tanumah.[37]

How can a bird descend from being quite plentiful to very scarce in only a few decades? It is likely to be a combination of factors. The bird's highland habitat is now heavily disturbed by residential and recreational development. Such development is especially problematic for Asir Magpies, which are rather shy of humans and generally avoid human sites. In some areas the all-important juniper forest is dying and not regenerating. This may be due in part to climate change, which has brought increasingly warmer and drier weather to the 'Asir Mountains over the last few decades. In other areas the juniper forests are being cleared for timber and fuel.[38] As a result, the species has retreated into a few small pockets of remaining suitable habitat, which are increasingly isolated from one another.

The Asir Magpie could go extinct within a decade. It would be a tragedy to lose one of the most extraordinary birds in the Kingdom and the one bird that is restricted entirely to Saudi Arabia.

Such habitat fragmentation is particularly problematic for species with low juvenile dispersal. Although juvenile dispersal has not been studied in Asir Magpies, we know that juvenile Eurasian Magpies generally disperse only 400 m from their natal territory.[39] If Asir Magpies are unable to effectively disperse from one habitat patch to another, then each small sub-population of Asir

THE ENTIRE GLOBAL POPULATION OF THE ENDANGERED ASIR MAGPIE OCCURS IN SAUDI ARABIA. LESS THAN 100 PAIRS REMAIN ON EARTH.

THE ASIR MAGPIE APPEARS TO BE HEADED FOR EXTINCTION.

Magpie will be incapable of exchanging genetic material. This can lead to significant genetic problems at the population level (such as inbreeding depression and genetic drift) that further reduce population size, sending the species into an extinction vortex.[40] Preliminary research into the movement patterns of Asir Magpies commenced in 2018. More such scientific studies are urgently required in order to save this precious bird from impending extinction. It would indeed be a tragedy to lose one of the most extraordinary birds in the Kingdom, and the only bird that is completely unique to Saudi Arabia.

PHILBY'S PARTRIDGE: ENDEMIC TO THE ARABIAN PENINSULA.

PHILBY'S PARTRIDGE (*ALECTORIS PHILBYI*)

The resplendent Philby's Partridge, with its rose-red beak, eye ring and legs, striking jet-black throat patch, and gorgeous multi-colored wing bars, was named after, the eminent British explorer, naturalist, and advisor to Abdul Aziz King of Saudi Arabia, Harry St John Bridger Philby (Sheikh Abdullah), who discovered several new species during his celebrated journeys across Arabia in the early 1900s. Oddly, we know far more about the explorer than we do about the partridge. Almost nothing has been recorded about this shy, somewhat elusive bird.

Philby's Partridge is one of 187 species belonging to the Phasianidae family, which includes the pheasants, partridges, turkeys and grouse. It belongs to the genus *Alectoris*, which contains seven species (including the Arabian Partridge) that occur over much of Europe, Asia and northern Africa, but Philby's Partridge is the rarest – only 25,000 breeding pairs exist in the wild. This marvelously goofy bird occurs only in southwestern Saudi Arabia and Yemen.

HABITAT

In Saudi Arabia, Philby's Partridge occurs in the southwest highlands from about Tayif southwards to Yemen. It is usually encountered above 2,000 m, but has been recorded as low as 1,280 m (near Najran). It appears to be almost absent from the western side of the 'Asir Mountains. It prefers agricultural habitats such as fallow, tilled or stubble fields and terraces, but also occurs in arid rocky areas, such as bare hillsides and boulder scree. Wherever it occurs, it is usually not far from areas of rough grass and scrub, which it uses to nest in or to retreat to when alarmed. It is rarely recorded in juniper and has never been recorded drinking, which suggests it is not particularly constrained by a lack of access to water.[41] It is a sedentary resident, but like all other *Alectoris* partridges it could wander attitudinally in periods of food shortage, such as during winter or extended drought.[42]

FORAGING ECOLOGY

Almost nothing has been published about the foraging behavior of Philby's Partridge. However, since the diet of all other *Alectoris* partridges is broadly consistent, then it is very likely that Philby's Partridge follows suit. That is, all *Alectoris* partridges are predominantly vegetarian, eating various seeds, grain, leaves, bulbous roots, shoots of grass and cereals, small fruits and berries, with some occasional terrestrial invertebrates (including the eggs and larvae). The diet may change according to season and local conditions: for instance, grass seeds dominate the diet during periods of high rainfall. In spring, breeding females might increase their intake of invertebrates, while grasses, legumes, bulbs and rhizomes may become more important during hard winters.[43] During the first days and weeks after hatching, partridge chicks feed on insects, but they soon progress to the adult diet of seeds and green material.[44]

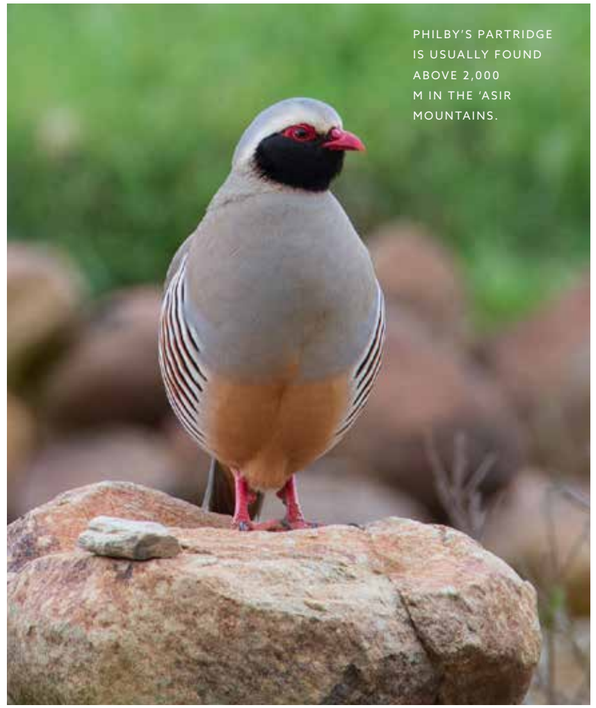
Alectoris partridges rarely drink, including those species living in hot arid environments. Studies of Chukar inhabiting arid or semi-arid environments in the US, Spain and the Sinai demonstrate that these partridges satisfy most of their water needs through the green component of their diet, and therefore usually only drink in summer.[45] This is likely to be the case for Philby's Partridge, which has never been observed to drink.[46]

Given their diet, Philby's Partridges spend most of their foraging time searching for food on or just below the ground. Thus they are vulnerable to a range of aerial predators, such as buzzards and eagles, as well as terrestrial predators, including Arabian Leopard,[47] Striped Hyaena, Honey Badgers, foxes, and other carnivores. Indeed, archeological studies show that humans have hunted *Alectoris* partridge in the region for at least 20,000 years[48] and continue to hunt Philby's Partridge at a low rate in the 'Asir.[49]

To minimize their risk of predation, Philby's Partridge are usually encountered in foraging groups of up to 15 or very rarely 20 birds, which tend to be most active in the early morning and late afternoon.[50] Studies of other partridges have shown that as group size increases, each individual bird can afford to be less vigilant for predators – and thus can spend more time foraging – because collectively there is a greater chance that at least one of the other birds in the group will detect any potential danger and quickly alert the group using an alarm call.[51] In other words, each individual bird benefits from the communal vigilance provided by the group.

Being such social birds, partridges have a wide range of vocalizations each used in a specific circumstance. Many vocalizations are used to maintain social cohesion between adult group members, including a number of dominance and submission calls. Other vocalizations keep the foraging group intact: if individuals in a covey have been separated, they can re-establish contact by standing upright, stretching out their neck and giving a loud shrill "rally call", which brings members of the group quickly back together. They also

Almost nothing has been recorded about the shy and elusive Philby's Partridge. Only 25,000 breeding pairs exist in the wild.



PHILBY'S PARTRIDGE IS USUALLY FOUND ABOVE 2,000 M IN THE 'ASIR MOUNTAINS.

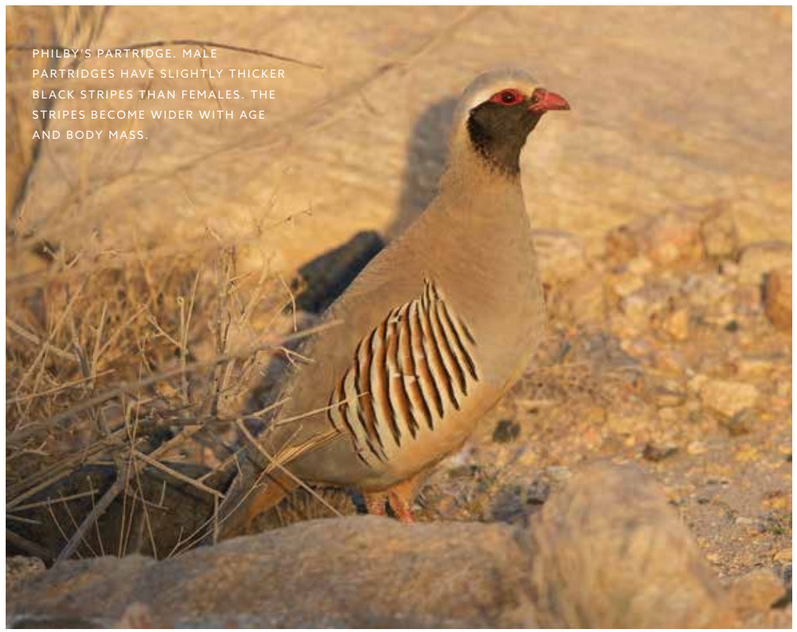
Partridges make different alarm calls depending on whether they detect a ground predator or an aerial predator. Significantly, group members respond appropriately to the different calls.

have an array of "family calls" that are used only between parents and their offspring. For example, female Rock Partridges (*A. graeca*) repeatedly utter monosyllables when foraging with their chicks, which respond with contentment notes when they are untroubled. The mother can direct the chick to a new food source by escalating these notes to specific phrases. The exact number of vocalizations varies between species, but in the case of the Chukar, which is very closely related to Philby's Partridge, scientists have identified no less than 18 discernible calls.[52]

Some of the calls made by *Alectoris* partridges are alarm calls. Experiments have demonstrated that foraging partridges make different alarm calls depending on whether they detect a ground predator or an aerial predator and that group members respond appropriately to the different calls. For instance, when a foraging partridge sees an aerial predator (such as a buzzard) it makes a short, guttural, low frequency alarm call. Group members then stop foraging and immediately scan the sky for a predator; they freeze, crouch, and remain vigilant while watching the potential predator's behavior. This is an appropriate response to an aerial predator: neither the one-off, low frequency alarm call or the freezing behavior draws attention to the group, while crouching prepares each bird to dash for nearby cover if the raptor makes a lunge for the group.

In contrast, when a foraging partridge detects a terrestrial predator (such as a Red Fox) it responds quite differently: it makes a much louder, harsh-sounding and higher frequency alarm call, which it gives repeatedly. Group members respond differently to this alarm call: they immediately become vigilant, scan for the predator, and then flee for cover. Again, this is a sensible response to a terrestrial predator: the frequent alarm calls not only indicate that the threat is imminent (as terrestrial predators are usually detected when they are much closer to the group and have probably already seen the birds), they might also serve to inform the predator that it has been detected, so it might as well leave. Sensibly, the birds don't crouch and freeze when they hear an alarm call for a terrestrial predator; instead they flee for their lives.[53]

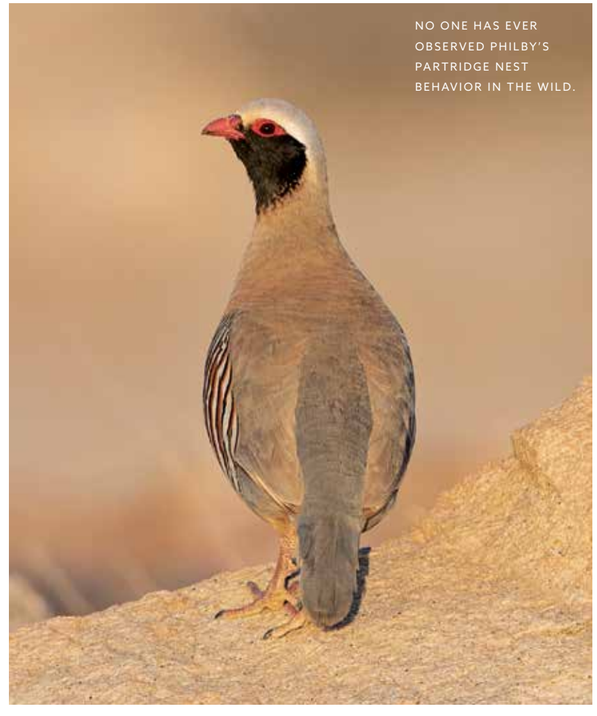
Foraging partridges also engage in a wide array of visual displays, many of which are aimed at establishing dominance within the group. These displays generally involve the beautiful multi-colored stripes or "flank bars" that are visible on the side of the bird's body. These vivid stripes, made up of a sequence of black, rufous and cream-colored feather patterns overlaying the background plumage, are a display of social rank, like an insignia on a military uniform: males have slightly thicker black stripes than females, and in both sexes the width of the black stripe increases with age and with body mass. The flank bands are visible at all times, but are especially prominent during agonistic displays when the feathers are aligned to exhibit almost perfectly continuous vertical black stripes. Birds in poorer condition appear unable to pigment the display feather completely to its edge creating uneven flank bars.[54]



PHILBY'S PARTRIDGE. MALE PARTRIDGES HAVE SLIGHTLY THICKER BLACK STRIPES THAN FEMALES. THE STRIPES BECOME WIDER WITH AGE AND BODY MASS.

The vivid, multi-colored stripes on the wings, which become especially prominent during displays, are an indicator of social rank, much like the bars on a military uniform.

One of the more common displays performed in *Alectoris* partridges is an aggressive display by the male usually towards other adult males, but also females and juveniles. It occurs year round, but is most common in late winter and spring when the dominant males attempt to underline their status in preparation for breeding. The display involves the male standing in an upright posture less than 3 m from another bird, and turning side on so that the side of the body is at a right angle to its opponent with its head and neck inclined away and with both wings withdrawn, thereby emphasizing the vertical flank bars. The feathers in the flank bars are held slightly erect to exhibit them as fully as possible. Sometimes the displaying bird will semi-circle around the target bird to accentuate the display. The target bird usually responds with a range of submissive behaviors – many of which involve suppressing the flank bars – including wing flapping, crouching and running away.[55] Such antagonistic display and displacement behavior increases as the breeding season approaches causing the winter foraging flocks to break down while breeding pairs begin to form.



NO ONE HAS EVER OBSERVED PHILBY'S PARTRIDGE NEST BEHAVIOR IN THE WILD.

BREEDING BIOLOGY

There is no published information about mate choice, courtship behavior or territorial behavior in Philby's Partridge (but see discussion of Arabian Partridge breeding biology below). In other *Alectoris* partridges, males increasingly make territorial calls, displace other males, and perform visual and vocal displays to attract females. The males that were most dominant during the winter flocking phase tend to obtain the largest and best territories. Pairs are socially monogamous but instances of successive bigamy have been reported for most *Alectoris* species and therefore similar behavior probably occurs in Philby's Partridge as well.

The parental roles of nesting Philby's Partridge are essentially unknown. In some partridges, the female builds the nest, in others the male builds, and in yet others both parents share the nest building duties. Only two nests of Philby's Partridges have ever been discovered, but the nests themselves were not described. Nevertheless, the nest is likely to resemble that of other *Alectoris* partridges, which build a scantily lined, shallow scrape in the ground, located under a low shrub or beside a rock. Ground nests are obviously highly vulnerable to predation, so nest site selection is a critical component of breeding success. For example, in Red-legged Partridges (*Alectoris rufa*), nests located in taller ground vegetation tend to be safer from predation.[56]

Clutch size in all studied species of *Alectoris* partridge normally ranges from 7–20 eggs, unless a second female has dumped her eggs in the nest resulting in over 30 eggs in the one nest. The two Philby's Partridge nests recorded to date contained 8 and 10 eggs, respectively, and normal clutch size in captivity is between 5–8 eggs. The eggs are white to pale buff colored, with mauve-brown spots or scattered blotches.[57] In all other *Alectoris* partridges, eggs are laid at intervals of 24–48 hours and the female only begins to incubate once the last egg is laid thereby ensuring that all eggs hatch roughly synchronously.[58] The length of the incubation phase of Philby's Partridge in the wild is unknown, but in other *Alectoris* partridges the eggs hatch after 22–26 days,[59] and in incubators at the Saudi Wildlife Authority's captive breeding facility at Tayif, Philby's Partridge eggs hatch after 25 days.[60]

Only two nests of Philby's Partridges have ever been discovered – and no one has ever observed their nest behavior in the wild.

Philby's Partridge may engage in double nesting in which the female lays two clutches about a week apart: the female then incubates one clutch while the male incubates the other clutch.

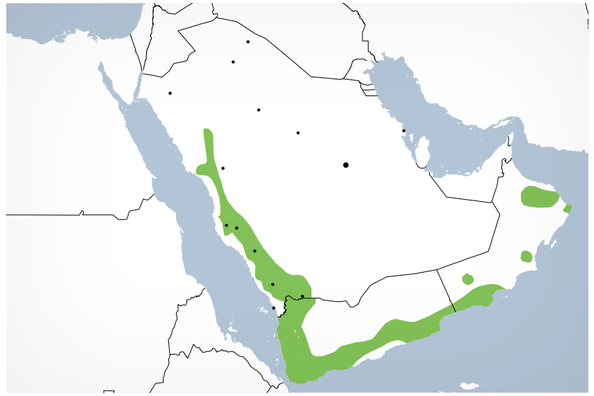
No one has ever observed Philby's Partridge nest behavior in the wild, so it is not known if the male assists the female at the nest (as occurs in some but not all other *Alectoris* partridges). In other partridges, the precocial young are brooded by the parents at the nest for a few days; they are able to fly very weakly after about 7–12 days and eventually reach adult size at between 50–120 days of age. The young reach sexual maturity at about one year of age and reach peak fertility at two years of age (laying a significantly higher number of larger eggs that have greater hatching success).[61]

Interestingly, all of the four best-studied *Alectoris* species demonstrate an extremely unusual "double nesting" mating system that could also occur in Philby's and Arabian Partridges. In double nesting, the female lays two clutches about a week apart. The female incubates one clutch while the male incubates the other clutch. The behavior, which is best documented in Red-legged Partridges, is quite common in productive seasons (when 50% of paired males were incubating a clutch) and less common or absent during dry seasons. A possible explanation for this fascinating behavior is that females have the physiological capacity to lay larger clutches in wet-spring years and, rather than "placing all their eggs in one basket", they separate their eggs into two clutches in case one of the nests is destroyed by a predator.[62]

CONSERVATION STATUS

The estimated global population of Philby's Partridges is around 25,000 pairs, with approximately 60% breeding in Saudi Arabia annually (*see* Table 1). As noted above, Philby's Partridge is the least abundant *Alectoris* partridge in the world. Nonetheless, it still has a large range and since it contains more than 10,000 mature individuals, the IUCN formally classifies the species as least concern.[63] Although the species readily utilizes agricultural landscapes, much of the natural habitat of Philby's Partridge has been lost to recreational and residential development in the last 2–3 decades, which is presumably impacting the species.[64] However in the absence of clear evidence for any declines the IUCN has listed the population as stable.[65]

ARABIAN PARTRIDGE: ENDEMIC TO THE ARABIAN PENINSULA.



ARABIAN PARTRIDGE (*ALECTORIS MELANOCEPHALA*)

Saudi Arabia is fortunate to have two endemic partridges breeding within its borders: Philby's Partridge and the Arabian Partridge. The two species are clearly distinct and do not interbreed.[66] The Arabian Partridge is the most abundant and one of the most widespread endemic birds in Saudi Arabia and yet very little is known about its basic feeding ecology and breeding biology. Fortunately other *Alectoris* partridges have been very well studied and can inform us about the likely behavior of this handsome endemic bird. It is the largest member of the genus *Alectoris* within the Phasianidae family (the pheasants, partridges, turkeys and grouse), and occurs along the fringes of western Saudi Arabia, Yemen and Oman.

HABITAT

In Saudi Arabia, Arabian Partridges occur in the western provinces from at least 26°N (between al-Wajh and al-'Ula, north of Medina) south to Yemen. Evidently, Arabian Partridges occur across a much wider range of habitat types than Philby's Partridge because they can be found at any altitude (from near sea level to the highest peak in Saudi Arabia), in almost any landscape (including areas of limestone, sandstone, granite and harrat), in a wide variety of habitat types (from arid acacia scrub to highland juniper forest to cultivated terraces), and in almost any aspect (including hills, mountains, upland plains, wadis and ravines). Further, they can be found in areas with frequent rainfall where water is freely available to areas that are quite arid. Within this broad range of habitats, they seem to prefer stony areas with a certain ratio of rocks, boulders, vegetation cover, trees and bushes.[67] Unlike Philby's Partridge, the Arabian Partridge drinks regularly if water is available, but its distribution is not limited to areas containing accessible water. In the northern parts of the range, for example, it occurs in areas that lack surface water for much of the year.[68] Evidently, like other *Alectoris* partridges it can obtain enough water from its diet.[69] The Arabian Partridge is generally sedentary, though it may occasionally wander altitudinally during periods of poor weather or food shortage.

THE ELUSIVE ARABIAN PARTRIDGE CAN BE FOUND IN THE WEST SOUTH FROM AROUND AL-'ULA.

At the start of the breeding season males attempt to court females by "waltzing" around prospective mates. Once pairs have formed, however, the waltzing stops.

FORAGING ECOLOGY

Arabian Partridges enjoy the predominantly vegetarian diet that typifies all *Alectoris* partridges. They have been recorded eating a wide variety of plant matter, including seeds, green leaves, grasses, acacia buds, grains (barley, wheat), bulbs, shoots, and Rosehips, as well as a small number of invertebrates. Most of the diet is obtained from the ground or low vegetation, though they do occasionally clamber into bushes or trees to feed. Most foraging and drinking occurs during mornings and evenings, while much of the rest of the day is spent roosting in tall trees.[70]

Arabian Partridges usually forage in groups of less than 15 birds (although a group of 27 has been reported).[71] Foraging groups are maintained through frequent contact calls that are generally the loudest and deepest of any *Alectoris* partridge.[72] Indeed, like all *Alectoris* Partridges, the Arabian Partridge has a wide variety of vocalizations and displays used in specific contexts (*see* Philby's Partridge).

BREEDING BIOLOGY

Although almost nothing is known about the breeding biology of the Arabian Partridge, other *Alectoris* partridges have been the subjects of some of the most important studies of mate choice in birds. Fortunately, many of the results of these studies can shed light on the breeding biology of both the Arabian and Philby's Partridge.

Testosterone levels in males increase as the breeding season approaches, triggering courtship behavior, male-male contests and territoriality, all of which involve a range of specific vocal activity and ritualized visual displays. Males become particularly vocal at sunrise and sunset crowing from prominent rocks, and begin to chase other males around the hillsides to assert dominance.[73]

Females are attracted to males with more red around the beak, eye ring and legs, which are signals of individual quality and health.

At the start of the breeding season male *Alectoris* partridges attempt to court females by "waltzing" around prospective mates. The waltzing male dances rapidly around the female in a 5–10 m circle or figure-of-eight, holding its head and neck forward, keeping its body horizontal, raising its tail to be parallel with the ground, and spreading and extending its wings in such a way that the beautifully striped flank feathers are especially prominent (these flank stripes are a status signal: *see* discussion in Philby's Partridge). It may also ruffle its feathers, particularly around the head and rump, to exaggerate its body size. The bird will pause momentarily about one meter in front of the female to emphasize the black bars on the side of its body and then resume the waltz, this time in the opposite direction. The male continues to prance about like this for several minutes until the female runs or flies away, or until another male intrudes. The waltzing male will act either aggressively or submissively to the intruding male, depending on its relative social status. Females that do not leave the waltz may be signaling their approval of the male, though the waltz does not trigger copulation. Once pairs have formed, the waltzing stops.[74]

What aspects of male morphology are the females assessing during these displays? Experiments in other *Alectoris* partridges have shown that females prefer to mate with larger, dominant males.[75] Evidence suggests that this is likely to be the case in Arabian Partridges as well: male Arabian Partridges are almost 40% heavier than females,[76] making them the most size dimorphic of all the *Alectoris* partridges, presumably as a result of intense female preference for larger males. Such a high level of sexual size dimorphism is usually correlated with a polygynous mating system,[77] which suggests that high quality male Arabian Partridges may mate with multiple females in a breeding season.

Females are also attracted to males with more red around the beak, eye ring and legs, which are signals of individual quality and health in partridges. This is because birds lack the physiological machinery required to synthesize the pigments (called carotenoids) required to actually produce this red plumage. Instead, they must ingest carotenoids in their diet, convert them into a useable form, and then redistribute them to the specific parts of the body to be displayed in their red ornaments. Birds that are consistently better foragers ingest more carotenoids and are therefore able to maintain brighter red ornaments.[78] Furthermore, the carotenoids used to produce red ornaments are also antioxidants and immune-enhancers. Therefore birds with brighter red ornaments are not only better foragers, they are also healthier birds with a stronger immune system,[79] which are obviously desirable qualities in a potential mate.

ARABIAN PARTRIDGE. IN PARTRIDGES, MALES WITH MORE RED IN THE BEAK, EYE AND LEGS TEND TO BE BETTER QUALITY BIRDS WITH HIGHER REPRODUCTIVE SUCCESS.

The amount of redness in the bill and eye ring of partridges changes over the course of the year, becoming more intense as the breeding season approaches. This is because testosterone (which surges at the onset of the breeding season) enhances carotenoid absorption and mobilizes the red pigments into ornamental traits.[80] Moreover, the extent of redness varies within individuals in response to their current nutritional or health status. For example, birds that have recently lost weight due to hunger display less red in the eye ring and beak.[81] The eye ring in particular is very sensitive to nutritional status, losing redness after only a few days of hunger.[82] Further, birds that are infected with intestinal parasites or other diseases also display less red in the bill and eye rings because the carotenoids have been redirected to fight the infection.[83] Likewise, birds currently experiencing physiological stress (with higher corticosterone levels) exhibit less redness.[84]

Accordingly, experiments have shown that both male and female partridges prefer to mate with individuals that have more red ornamentation. Females with redder beaks and eye rings (i.e. high quality birds) partner with males with redder beaks and eye rings – a process known as assortative mating.[85] Researchers have proven that partridges are genuinely able to assess the quality of potential mates based solely on the amount of redness in their face. In one neat experiment, female Red-legged Partridges preferred to mate with males that had the amount of red in their faces artificially increased with paint. Furthermore, the females invested more energy in reproduction when partnered with a male with additional red ornamentation: they laid their eggs earlier and produced more eggs than those that had mated with males with a normal level of redness in the face.[86]

The foraging groups break down once pairs have established, though unmated males might remain in smaller foraging flocks throughout the nesting season. Pairs establish their breeding territory and commence nest building. Unfortunately there is almost no information about the nesting behavior of Arabian Partridges. Indeed, despite the estimated 400,000 pairs that breed annually in the region (including 150,000 pairs that breed annually in the Kingdom) not one nest has ever been found in the wild.

Based on the breeding biology of other *Alectoris* partridges, the nest is likely to be little more than a slight depression (perhaps with some meager lining) hidden under a shrub, amongst dense ground vegetation or tucked up against a rock. Either the male or female or both could choose the nest site and build the nest. Clutch size is unknown, but likely to range from 7–20 eggs, with some unusually large clutches the result of egg dumping by a second female. Eggs will be laid in 1–2-day intervals with incubation commencing only once the entire clutch is laid, thereby resulting in all eggs hatching synchronously.[87] The smooth, white eggs of Arabian Partridge raised in incubators (for captive breeding purposes) take 25 days to hatch,[88] which is about average for *Alectoris* partridges in the wild.[89] The precocial chicks will be able to fly weakly after about 7–12 days and will reach adult size between 50–120 days of age. Although no nests have been recorded, 14 broods have been found in the wild ranging in size from 4–12 chicks.[90] The young will probably become sexually mature after one year and will reach peak fertility a year later.[91]

Two tantalizing strands of evidence hint that Arabian Partridges might exhibit the unusual double nesting behavior reported for some other *Alectoris* partridges where the female lays two clutches in succession and incubates one nest while the male incubates the other. First, females in captivity have laid more than 50 eggs in eight months,[92] which suggests some individuals have the physiological capacity to produce enough eggs for two nests. Second, broods containing chicks of different sizes have been reported in the wild,[93] presumably an amalgamation of more than one clutch.

A JUVENILE ARABIAN PARTRIDGE ON A FARM IN THE 'ASIR LOWLANDS. NO ARABIAN PARTRIDGE NEST HAS EVER BEEN DISCOVERED IN THE WILD.

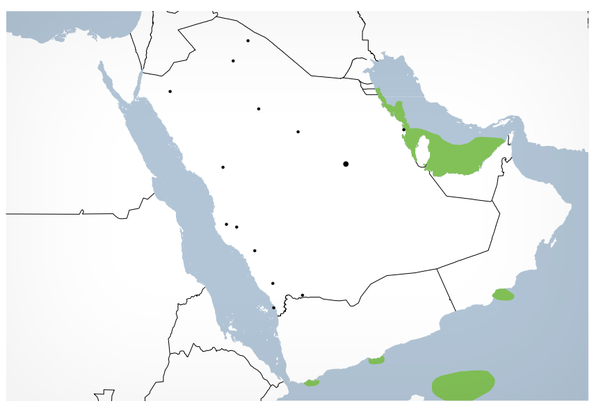
Despite a global population of 400,000 annual breeding pairs (including 150,000 pairs in Saudi Arabia) not one Arabian Partridge nest has ever been found in the wild.

FEMALE ARABIAN PARTRIDGES MAY LAY TWO CLUTCHES IN SUCCESSION. THE MALE INCUBATES THE FIRST CLUTCH WHILE THE FEMALE INCUBATES THE SECOND.

CONSERVATION STATUS

The global population of Arabian Partridges is estimated at around 400,000 pairs, with almost 40% of the world's population breeding in Saudi Arabia (*see* Table 1). As a result of this healthy population size and wide distribution, the IUCN lists the species as least concern.[94] Arabian Partridges are often caught, reared and traded alive for food, and frequently hunted.[95] Further, the species is likely to be affected by habitat degradation through grazing by domestic stock, conversion to agricultural land, and recreational and residential development. Nonetheless, in the absence of direct evidence for population declines the IUCN lists the population as stable.[96] Within Saudi Arabia, the species occurs in Rayda Reserve within 'Asir National Park.

SOCOTRA CORMORANT: ENDEMIC TO THE ARABIAN PENINSULA.



SOCOTRA CORMORANT (*PHALACROCORAX NIGROGULARIS*)

Gazing at an immense flock of tens of thousands of Socotra Cormorants flying in formation across an Arabian Gulf sunset is surely one of the most sublime experiences for any birdwatcher in the Kingdom. These intensely gregarious birds are almost always seen in vast numbers, be it foraging at sea, nesting on desert islands, or roosting on sea cliffs. Yet the large numbers of Socotra Cormorant hides the fact that this endemic seabird has suffered precipitous declines in recent decades and is now vulnerable to extinction.

The Socotra Cormorant occurs in two distinct subpopulations. The large northern population breeds in the Arabian Gulf on islands belonging to Saudi Arabia, Bahrain, United Arab Emirates and Qatar. It could also conceivably breed on islands off Iran, although there has been no confirmed breeding there since 1972.[97] The much smaller southern population breeds on islands in the Arabian Sea off Oman and in the Gulf of Aden south of Yemen, including a small population at Socotra Island, and often forages off the north coast of Somalia between November to April.[98] They have been regarded as a vagrant to the Red Sea, but large numbers have been reported from Eritrea (and may even breed there).[99] It is unknown if birds move between the two subpopulations.

Globally, there are 34 species of cormorant in the Phalacrocoracidae family, which are distributed over most of the world, including 29 species in the same genus as the Socotra Cormorant (*Phalacrocorax*). Two cormorants occur in Saudi Arabia, the Great Cormorant (which is a regular winter visitor to Saudi Arabia) and the Socotra Cormorant. The name, Socotra Cormorant, stems from the fact that Western scientists first discovered the species on the island of Socotra in 1898.[100]

HABITAT

Socotra Cormorants occur exclusively in marine environments, foraging widely over the Arabian Gulf during the non-breeding period. They come to land only to breed, rest and roost. Indeed, their preference for marine habitat is so strong that they even avoid flying over islands. They breed on small desert offshore islands that contain sandy or loose gravel substrate, which they use for nesting.[101] They rest and roost on undisturbed, predator-free sandbars, coastal cliffs and rocky islets, often far from their breeding colonies, and often in considerable numbers. For instance, an estimated 18,000 birds have been recorded roosting at an isolated sandbar at Ras az-Zawr (northern tip of Jubail Conservation Area) in the Eastern Province.[102] Roosts are generally tightly packed, possibly to maximize the amount of shade cast on the feet.[103]

FORAGING ECOLOGY

Socotra Cormorants usually forage offshore in stunning aggregations that can contain tens of thousands of birds. By using GPS and temperature–depth loggers attached to 20 individual Socotra Cormorants (breeding at Siniya Island in the UAE), researchers have been able to obtain considerable information about the dynamics of these extraordinary communal foraging bouts.

In the morning, both males and females aggregate on the beach near the breeding colony (sometimes spilling out into the water forming a massive raft of thousands of floating birds) until they eventually depart *en masse*. The feeding group flies as a dense flock close to the water surface, often in multiple scattered lines of 10–50 birds flying in a V formation to reduce the aerodynamic costs of flight. The flock follows an irregular path as individuals scan the sea surface for shoaling fish.[104] The separate streams of birds probably scan different parts of the water surface and notify other streams when prey is discovered.[105] On average, a feeding flock will fly for around 1.3 hours until a suitable school of fish is discovered – and then the feeding frenzy begins. Individual birds start diving from the surface, chasing after fish, and catching them underwater with their bills, before consuming them at the surface away from other birds. On average, each bird dives to a depth of 7 m over a 24-second duration, though some pursuits last 76 seconds taking the birds 24 m below the water surface, descending at a staggering 3 m per second. Feeding bouts last from 36 minutes to over 3.5 hours, but most last around 100 minutes. Satellite tracking shows that the entire breeding colony forages at the same location, with all birds within about 500 m of each other. Over 44,000 birds can

Gazing at an immense flock of tens of thousands of Socotra Cormorants flying in formation across an Arabian Gulf sunset is surely one of the most sublime experiences for any birdwatcher in the Kingdom.

THE SOCOTRA CORMORANT FORAGES AT SEA. IT COMES TO LAND ONLY TO REST, ROOST AND BREED.

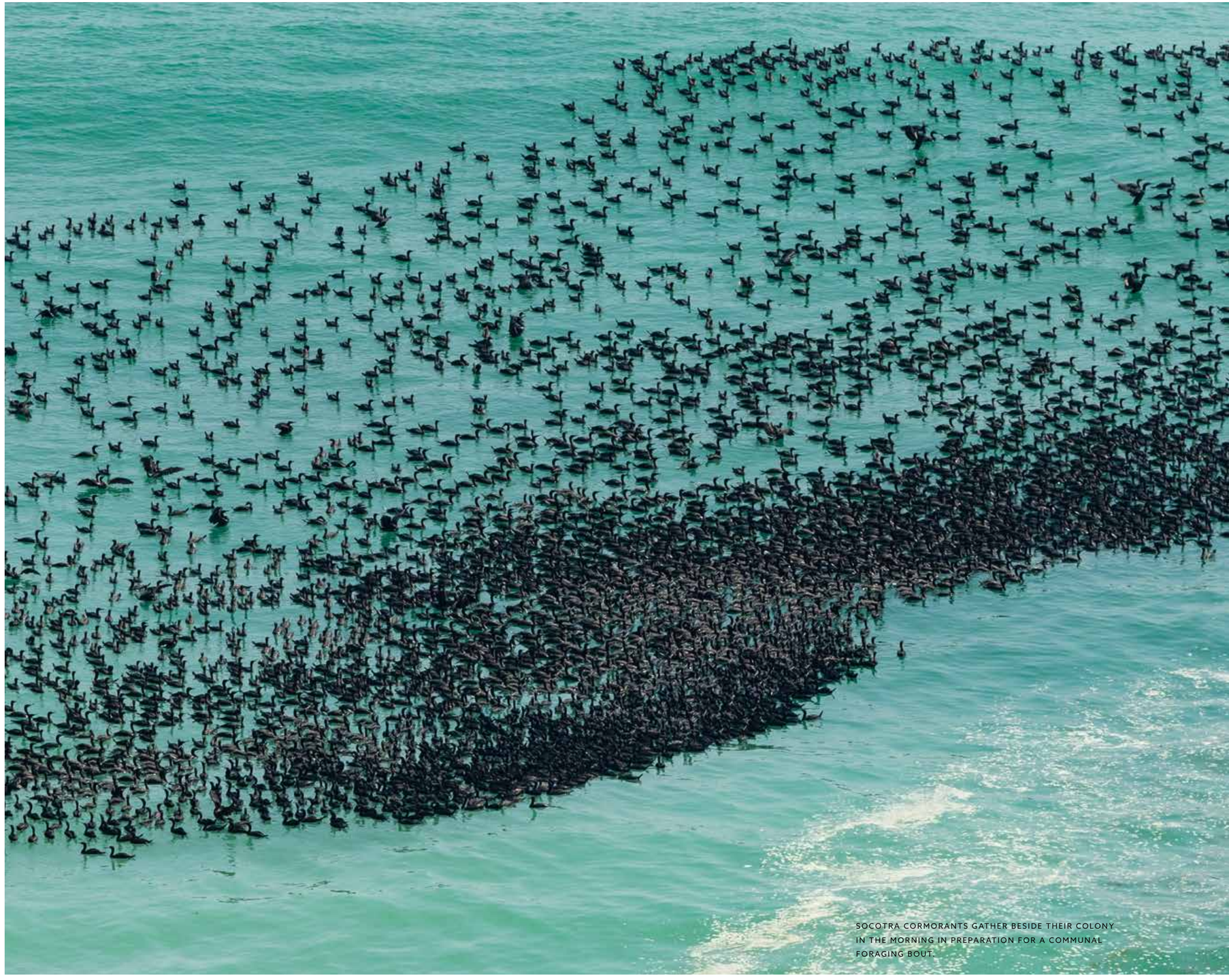
VAST COLONIES OF SOCOTRA CORMORANTS FLY LOW OVER THE OCEAN IN SEARCH OF SCHOOLS OF FISH. FORAGING TRIPS CAN LAST FOR OVER 7 HOURS.

What an incredible sight to behold: a Socotra Cormorant surging through the water, kicking its powerful legs in pursuit of its prey, and then seizing its victim in its bill.

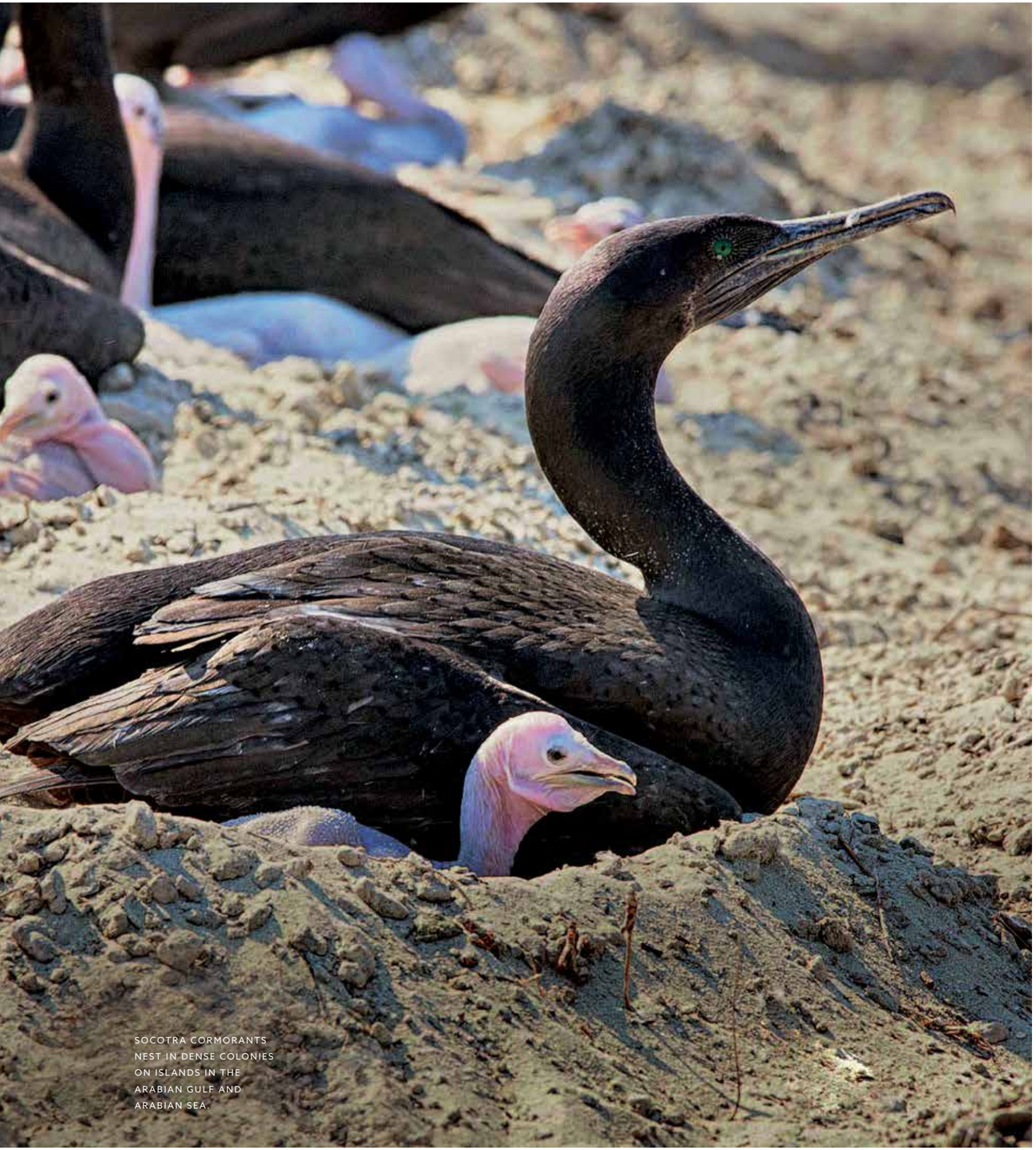
join a feeding frenzy, with each individual bird diving up to 240 times per foraging bout, generally only a few meters from a neighboring bird. Because Socotra Cormorants in the Arabian Gulf forage in shallow water (usually only 10 m deep), they effectively trap the fish between the seafloor and the surface. The foraging flock works communally to drive the fish toward the shoreline, condensing the school into ever-shallower water.[106]

It must be an incredible sight to watch a Socotra Cormorant surging through the water, kicking its powerful legs in pursuit of its prey, and ultimately seizing its victim, while thousands of other cormorants charge after their targets at the same time with hundreds of thousands of schooling fish darting and scattering in all directions. The mêlée often attracts other seabirds, such as booby birds, gulls and terns. Other predators are drawn to the scene too, such as dolphins and sharks, which circle below and make tactical lunges into the chaotic prey.

WHEN A SCHOOL OF FISH IS FOUND, SOCOTRA CORMORANTS PLUNGE INTO THE WATER AND BEGIN CHASING AFTER THEIR PREY.



SOCOTRA CORMORANTS GATHER BESIDE THEIR COLONY IN THE MORNING IN PREPARATION FOR A COMMUNAL FORAGING BOUT.



SOCOTRA CORMORANTS NEST IN DENSE COLONIES ON ISLANDS IN THE ARABIAN GULF AND ARABIAN SEA.

During the breeding season, each bird undertakes usually one offshore foraging trip each day, spending on average a total of 48 minutes per day under water actively pursuing fish. On average, each foraging trip (flight plus foraging time) lasts 3.7 hours, but some last over 7 hours, flying at an average of 45 kilometers per hour with a top speed of 89 kilometers per hour. Birds from the Siniya Island colony forage from 3–64 kilometers from the breeding island, covering up to 157 kilometers, and never venturing more than 18 kilometers offshore.[107] Similar distances have been estimated for flocks travelling from islands off Bahrain.[108] Once the feeding bout is complete, the flock returns in a direct route to the colony in a long, single file or V-shaped formation.[109] Interestingly, birds that remained at the colony are able to obtain information from the returning birds. That is, they can identify that colony members are returning from a successful foraging trip and follow the direction of their flight, thereby finding the school of fish much more easily and quickly.[110]

While most feeding occurs offshore, Socotra Cormorants can also hunt inshore in spectacular communal feeding bouts lasting up to 30 minutes. Thousands of individual birds appear to work cooperatively to corral fish against the shore where they then pick off individual fish to eat.[111]

Globally, cormorants have frequently come into conflict with fishing communities because of concern over competition for fish. Fortunately, the small fish species consumed by Socotra Cormorants are not the species targeted by commercial fisheries in the Arabian Gulf. Local fisheries primarily land large demersal or reef fish, whereas cormorants eat small (45–180 millimeters) pelagic fish, mostly of low commercial value.[112]

The fish consumed by Socotra Cormorants depends largely on local availability. As such, there is considerable variation in the diet between seasons, years and locations. For example, at Siniya Island where the foraging ecology of Socotra Cormorants has been studied in detail, the diet switched at least three times in the space of only 12 months from (i) primarily Sailfin Flying Fish, to (ii) a mixture of Blue-stripe Sardine, Pink-eared Emperor and Sailfin Flying fish, to (iii) almost entirely Anchovies.[113] By comparison, at Hawar Island (Bahrain) the diet consisted of Sardines, Scads, Silverside, Spotted Half-beak and Streaked Rabbit-fish.[114] Thus, the dominant fish species in the Socotra Cormorant's diet appear to be either baitfish or non-target species in local fisheries.[115]

Some studies have demonstrated that cormorants have a positive effect on fisheries and ecosystem dynamics. Not only do they usually prey on fish species of smaller size classes that are not targeted by fisheries, they selectively feed on sick fish and cause density-dependent regulation of fish, thereby enhancing fish diversity and ecosystem functioning, which ultimately benefits fisheries.[116]

BREEDING BIOLOGY

Socotra Cormorants nest in stunning breeding colonies that range in size from 50 to tens of thousands of pairs. In the Arabian Gulf, most breeding usually occurs between September and April, coinciding with cooler conditions.[117] However, colonies can nest at irregular times, presumably in response to a surge in local fish availability. Thus the breeding season can vary considerably between locations, between years and even between neighboring breeding colonies. Within most colonies, nesting is highly synchronized with all pairs laying eggs within a 1–2 week window. However, some colonies exhibit internal asynchrony where one section of the colony may commence nesting just as another section has almost finished.[118]

The small fish consumed by Socotra Cormorants are not the species targeted by local commercial fisheries. Indeed cormorants may have a positive effect on fisheries and ecosystem dynamics.

Like most seabirds, Socotra Cormorants form socially monogamous pairs. Although both sexes appear all black from a distance, they actually possess subtle plumage ornaments that are presumably important in mate choice. For instance, as the breeding season approaches adults develop a purplish to oily green gloss, a conspicuous tuft of long white filoplumes around the ears, and some sparse white filoplumes around the lower back, rump, rear flanks and thighs.[119] These filoplumes disappear towards the end of the breeding season, which is a strong indicator that they are costly to produce and thus an advertisement of individual quality that is used in mate choice during pair formation.

The nest is an unlined shallow scrape surrounded by a slightly raised bowl-shaped mound (around 70 centimeters in diameter and 15 centimeters deep) composed of gravel, compact sand and debris built directly onto open ground. Each nest is located usually around 80 centimeters from neighboring nests.[120] Nest density is highest in the center of colonies,[121] which suggests that there is some advantage in nesting at the center (such as additional protection from aerial predators). Most nests contain 2–3 eggs (mean 2.4). However in some instances as many as 11 eggs have been found in a single nest,[122] which implies that females occasionally dump their eggs into other nests in the hope that neighboring females might rear their young.

Socotra Cormorants can nest in stunning breeding colonies containing tens of thousands of pairs.

SOCOTRA CORMORANT JUVENILES LEAVE THE NEST AND FORM CRÈCHE. THESE 20-DAY OLD BIRDS WAIT DURING THE DAY FOR THEIR PARENTS TO RETURN FROM THEIR DAILY FORAGING BOUT AT SEA.

Both parents incubate the eggs and feed the young. Generally one adult incubates in stints of 5–7 hours while their partner forages at sea, after which the incubating adult switches with the returning bird. Incubation has been estimated as 21 days at Hawar Islands (Bahrain) and 24–27 days in Siniya Island (UAE).[123] If these estimates are accurate then the Socotra Cormorant has perhaps the shortest incubation period of any cormorant (other similar sized cormorants usually incubate for around 30 days).

Hatchlings are blind and naked and are therefore highly vulnerable to overheating and dehydration.[124] Thus, any shaded areas provide welcome relief, and are the most sought after nest sites in a colony. Consequently, nest density on Siniya Island is highest in the shaded areas provided by plantations of acacia and Ghaf trees. Only the highest quality birds are able to compete for and successfully establish a nest site in these preferred areas: accordingly, females nesting in shaded areas lay significantly larger eggs and have higher hatching success than females nesting in open areas.[125] However, most nesting islands utilized by Socotra Cormorants contain no shade whatsoever.

By 10–20 days of age, the chicks have developed a complete cover of white, downy feathers. During this time the chicks become increasingly mobile, at first forming small crèches near their nest site, which are guarded by one or more surrounding adults. After about 20 days, the chicks grow a second coating of downy feathers and begin to wander further from their nest sites forming larger crèches sometimes containing thousands of chicks.[126] Parents returning from sea with food somehow locate their chick among a crèche of hundreds or thousands of very similar looking chicks, providing around 2–3 meals per day.[127] Gradually parents reduce their provisioning rate, forcing the large chicks to undergo a period of starvation. Consequently, larger chicks sometimes opportunistically cannibalize newly hatched chicks.[128] Nonetheless, on undisturbed islands more than two-thirds of chicks survive to fledging age (sometime around 53 days of age).[129] Like other cormorants, the juveniles probably remain dependent on the adults for 6–12 weeks.[130]

The longevity of Socotra Cormorants is not known; however other similar sized cormorants delay sexually maturation until their second or third year and live more than 17 years in the wild.[131]

CONSERVATION STATUS

The global population of Socotra Cormorants is estimated at around 110,000 pairs. About half the world's population breeds on islands in the Gulf of Salwa belonging to Saudi Arabia, Bahrain and Qatar, with perhaps 35,000 pairs breeding on Saudi Arabian islands. In other words, almost one in three of the world's Socotra Cormorants breed in Saudi Arabian waters (*see* Table 1). Entire breeding colonies switch islands regularly, which makes estimating population size or trends difficult.[132]

The IUCN lists the species as vulnerable because it has a small range (only 13 colonies are currently known to be active), which is suspected to be undergoing a rapid decline.[133] In the Arabian Gulf, at least 12 breeding colonies have become extinct since the 1960s, representing the loss of an estimated 80,000 breeding pairs or more than 40% of the global population.[134] Some estimates suggest the losses have been much greater. For instance, Zirku Island off UAE is thought to have supported a colony of between 50,000–250,000 breeding pairs in 1978, but by 1981 it was extinct.[135]

In Saudi Arabia, the number of breeding pairs declined by more than 75% between 1980 and 1992 alone,[136] and it is likely that further losses have been suffered since then. Breeding colonies in the northern Arabian Gulf have all but disappeared, and may now number fewer than 100 pairs.[137]

A number of contributing factors are responsible for the precipitous decline of the Socotra Cormorant, with the main threat being the very high rate of coastal development on breeding islands. Other threats include human disturbance at nesting colonies (which allows wide-scale predation of eggs by large gulls, and contributes to chick dehydration), collection of eggs and chicks, marine oil spills, drowning in fishing nets and lines, recreational shooting, predation from introduced feral cats and overabundant native predators (specifically Arabian Red Foxes), ingestion of marine plastic debris, and the accumulation of marine pollutants such as heavy metals, PCBs (polychlorinated biphenyls) and neurotoxins.[138] Further, as a ground-nesting species, it is vulnerable to the effects of storms, such as the flooding of nests during heavy rains.[139] Of additional concern, if forming large communal flocks is important for finding and catching fish, then populations that undergo further declines may face difficulties in securing prey, thus further increasing the threat to the species.[140] Considering the large number of threats currently impacting the Socotra Cormorant, this species is surely one of the most vulnerable of the Arabian endemics, even though the population currently contains more than 100,000 breeding pairs.

In Saudi Arabia, the number of Socotra Cormorant breeding pairs declined by more than 75% between 1980 and 1992 alone.

JUVENILE SOCOTRA CORMORANTS AROUND 40 DAYS OLD. ALTHOUGH THEY STILL OCCUR IN LARGE COLONIES, NUMBERS HAVE DECLINED DRAMATICALLY IN RECENT DECADES. THE SPECIES IS NOW LISTED AS VULNERABLE TO EXTINCTION.

ARABIAN SCOPS-OWL: ENDEMIC TO THE ARABIAN PENINSULA.

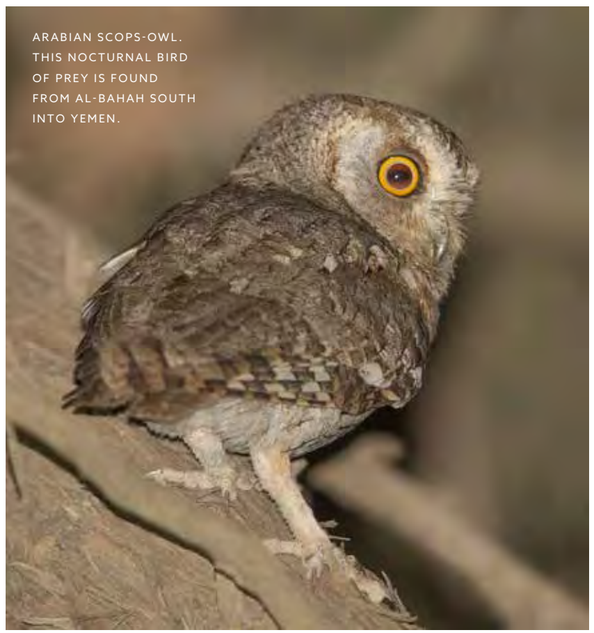
ARABIAN SCOPS-OWL (*OTUS PAMELAE*)

The Arabian Scops-owl is something of a mystery. In fact, it was only as recently as 2013 that it was formally recognized as a distinct species.

The Arabian Scops-owl is something of a mystery. There has been almost no information published about this strictly nocturnal bird of prey. In fact, it was only as recently as 2013 that the Arabian Scops-owls was formally recognized as a distinct species.

When Western scientists first discovered scops-owls in Arabia (in 1937 at Wadi Bishah in the 'Asir Province in southwest Saudi Arabia), they assumed it belonged to the same species as the scops-owl that lives across much of Africa.[141] Thus for decades this bird was known as the African Scops-owl and given the scientific name *Otus senegalensis pamelae*. However, recent studies have uncovered three lines of evidence that indicate the scops-owl that lives in Arabia is in fact a different species to the scops-owl that lives in Africa. First, the Arabian Scops-owl's song is higher pitched, harsher, has more prolonged notes, and sounds two-parted, due to a much quieter first note. Second, the Arabian Scops-owl has longer wings, much longer legs, and paler plumage with less distinct streaking (which are useful adaptations for living in a hot desert environment). Third, and most importantly, the Arabian Scops-owl is genetically distinct from the African Scops-owl: using mitochondrial DNA, the genetic distance between the scops-owls in Arabia and Africa is around 4%.[142] Thus, the scops-owl that lives in Saudi Arabia is a distinct species. It is now known as the Arabian Scops-owl and given the scientific name *Otus pamelae*.

There are more than 50 species of scops-owl worldwide, ranging from Arica in the west to Southeast Asia in the east, with many species in Indonesia, the Philippines, and various islands in the Indian Ocean. The Arabian Scops-owl occurs only in Saudi Arabia, Yemen and the Dhofar region of western Oman.



ARABIAN SCOPS-OWL. THIS NOCTURNAL BIRD OF PREY IS FOUND FROM AL-BAHAH SOUTH INTO YEMEN.

HABITAT

In Saudi Arabia, Arabian Scops-owls have been observed from al-Bahah south to Yemen. They have been recorded across a wide range of altitudes, from sea level (in Dhofar, Oman) to almost 3,000 m on Jabal Sawda' in the 'Asir, the highest peak in Saudi Arabia. Arabian Scops-owls live in a variety of habitats, but are usually found reasonably close to a freshwater source in open woodland or dry wooded slopes. They can be found in juniper woodland in the highlands, lush fig thickets in the western foothills and myrrh and acacia scrub amidst arid lands, rocky areas, and generally rather sparsely vegetated habitats, though they avoid pure desert regions. They are occasionally recorded around human settlements.[143]

FORAGING ECOLOGY

While there have been no published accounts of its diet or method of foraging, the Arabian Scops-owl is likely to feed primarily on a wide range of invertebrates (including beetles, grasshoppers, crickets, scorpions, spiders, moths, and earthworms) as well as occasional small vertebrates (particularly small reptiles, mammals, and perhaps birds), depending on local availability. This assumption is based on the diets of other scops-owls around the world. Every other species of scops-owl that has had any information recorded about its foraging ecology (n=29) has been reported to prey primarily on a wide variety of invertebrates and occasionally on small vertebrates.[144] The small size of the Arabian Scops-owl (18 centimeters; 62–71 grams) and the relatively weak talons characteristic of scops-owls further suggest that this species feeds primarily on invertebrates.

Arabian Scops-owls presumably forage in a similar fashion to other scops-owls, that is chiefly by dropping down from a perch to grab prey with their feet. They may also hunt on foot, actively searching for insects on the ground or in tree bark seizing small prey with their bill, or occasionally by catching moths in flight using their feet after a fast aerial pursuit. Small insects are swallowed whole, while larger prey is pulled apart with the talons and beak.[145]

Arabian Scops-owl living in mountainous desert environments are likely to undergo periods of energetic stress during cold arid winters when the availability of nocturnal invertebrates is drastically reduced. This has been demonstrated in the Kalahari Desert in South Africa where nocturnal, terrestrial arthropods are 85% less abundant during winter. Accordingly, the closely related African Scops-owl loses 13% of its body weight during winter. To help reduce its energetic requirements during these periods of low food availability, African Scops-owls use torpor on cold winter mornings. That is, individual birds are able to conserve energy by lowering their body temperature by over 8.5°C and reducing their metabolic rate by 23%.[146] Given that Arabian Scops-owls

Scops-owls may undergo torpor during cold mornings in order to survive the cold winters of southwest Saudi Arabia.

THE ARABIAN SCOPS-OWL CAN SEE EXTREMELY WELL IN NEAR TOTAL DARKNESS.

The retinas in the huge forward-facing eyes of Arabian Scops-owls are specialized to perform in incredibly low light. Their vision is one hundred times better than that of any diurnal species in low light conditions.

forage in areas of unpredictable rainfall and low productivity, it is likely that they too undergo torpor during cold mornings in order to survive the chilly winters of southwest Saudi Arabia.

Arabian Scops-owls have several conspicuous features that are clearly adaptations for a strictly nocturnal, predatory lifestyle. First, since Arabian Scops-owls sleep during the day in open habitats, they need to be exquisitely camouflaged to reduce the risk of being spotted by diurnal predators. Accordingly, the dark streaking and barring on the pale brownish-grey feathers ensures the Arabian Scops-owl resembles wood bark. During the day individual birds nestle into a tree hollow, close their bright yellow eyes, and blend seamlessly into their woody background where they remain silent and motionless while waiting for night to fall.

THE WIDE, FLAT FACE OF THE ARABIAN SCOPS-OWL ACTS LIKE A SATELLITE DISH, FUNNELING MINUTE SOUNDS TO THE EARS.

Under the night's cloak of darkness, the Arabian Scops-owl hunts for invertebrates and small vertebrate prey. To achieve this, the Arabian Scops-owl has a suite of adaptations that enable it to see extremely well in very low light conditions. One such adaptation is the enormous eyes of the scops-owl. In the visual system of vertebrates, light reflecting from objects in the environment enters the eye and casts an image on the retina. The brain then deciphers this image. Accordingly, the eye of the Arabian Scops-owl is almost twice as large as diurnal birds of equal size, thereby allowing a much larger image to be projected onto the retina. In Arabian Scops-owls (and owls in general), the eye is so large that it occupies more than 50% of the skull's volume (by comparison, the human eye occupies less than 5% of skull volume). What's more, owl eyes are not spherical; they are tubular, thereby providing an even larger surface area for the retina, further improving visual acuity at low light levels.[147]

Not only are the eyes of the Arabian Scops-owl large, they also face forward. This has two significant benefits. First, it allows the bird to receive light from the same subject in both eyes simultaneously, which improves acuity and contrast sensitivity at low light levels. Second, it provides the binocular (stereoscopic) vision required to accurately judge distance, which is essential for a hunter.[148]

The retinas in the eyes of nocturnal owls are specialized to perform well in incredibly low light situations. Like most vertebrates, the owl's retina contains two broad types of light receptors, known as rod and cone cells. Rod cells detect shapes and motion and enable vision at low light levels, while cone cells enable color vision and provide high image resolution. In the retinas of diurnal birds, cone cells are more abundant than rod cells. In contrast, the large, elongated retinas of nocturnal owls have far more rods cells than cone cells. In fact, owl retinas have over *30 times* more rods than cones,[149] enabling owls to see exceptionally well in the dark. Thus, owl vision is one hundredfold better than that of any diurnal species in low light conditions.[150] Laboratory experiments have demonstrated that nocturnal owls can see well enough to catch prey in almost total darkness. The Common Barn-owl for instance can see dead (i.e., unmoving) prey from two meters away in only 0.0000007 lux, which is almost complete darkness (for comparison, a clear moonless night provides 0.002 lux).[151]

Although owls can see supremely well in low light conditions, most have surprisingly poor vision in daylight. They lack the ability to judge depth, distinguish small objects, and to recognize contrasts in color or light.[152] Thus, it is unethical to flush an owl from its daytime roost.

Another prominent feature of the Arabian Scops-owl is the conspicuous facial ruff that gives the head a flat disk-like appearance. Amazingly, the facial ruff provides owls with exceptionally sensitive hearing: it acts like a satellite dish that collects sound waves and directs them to the ear openings, which are located at the edge of the ruff beside the eyes (note: the ears are not located in the so-called "ear tufts" at the top of the scops-owl's head. The ear tufts are not ears at all – they are display feathers that can be raised or lowered as a silent form of communication). This extraordinary adaptation allows the Arabian Scops-owl to hear the tiny rustling sounds of its invertebrate prey – sounds that are completely inaudible to human hearing – and to locate these sounds with extreme precision.[153]

An owl's ruff is composed of two broad types of feathers. First, "reflector feathers" around the border of the ruff are densely branched to create an intricate network of fine feather barbules that collect, filter and amplify any sound waves they encounter and then funnel that purified sound toward the ear openings. Second, the facial ruff contains "auricular feathers" that protect the reflector feathers from dust, which would otherwise diminish the effectiveness of the ruff.[154] Preventing dust particles from accumulating on the ruff is obviously especially important in the sandy deserts of Saudi Arabia.

If the facial ruff is damaged, the bird has considerable difficulty in locating prey.[155] To maximize the effectiveness of the ruff, the bill points downward to avoid interrupting sound waves as they travel towards the facial disc. In addition, prominent auricular feathers surround the bill (as if the bird has a bushy moustache) as an added protection from dust. These auricular feathers have fewer barbs and can be retracted while eating to ensure that food particles do not become trapped and impede the function of the ruff. Finally, the ruff feathers are rigid so that they do not deform in flight, enabling owls to hear equally well while flying.[156]

To process all of the sounds received by the extremely sensitive auditory system, the area of the brain associated with hearing – the medulla – is about three times more complex in owls than in other birds of equal size. The complex medulla enables owls to determine the direction of sound by distinguishing which ear received the sound first. Owls can detect when one ear receives a sound before the other by as little as three hundred-thousandths of a second. When the owl detects the sound of a prey species rustling in the undergrowth, it turns its head until the sound arrives in both ears simultaneously. It then knows its prey is directly in front of it. Furthermore, the ears of the owl are located in asymmetrical positions on the skull – that is, the left ear is set higher than the right ear. Thus, an Arabian Scops-owl can distinguish if the sound is coming from higher or lower than its gaze. If a sound is emanating from below the owl's line of sight, it will be louder in the right ear.[157] Thus, when an Arabian Scops-owl detects the faint rustle of an invertebrate, it turns its head rapidly toward the source, identifies the location of the target and plunges headlong into the darkness and lands directly on its prey.

The facial ruff provides owls with exceptionally sensitive hearing: it acts like a satellite dish that collects and directs sound waves to the ear openings.

In order to hear the minute sounds made by invertebrates, the Arabian Scops-owl must make no noise, especially in flight as it approaches its prey. Accordingly, the feathers and wings of nocturnal owls are adapted to enable silent flight. Precisely how owls achieve silent flight is still uncertain. While wing design enables the owl to fly slowly, silent flight is not simply a consequence of lower flight speed.[158] Instead, it appears that multiple aspects of wing and feather design all work together to eliminate sound, including serrations on the leading edge of the wing, fringes on the trailing edges of each feather, and even the shape of the feather barbules.[159] Humans cannot hear an Arabian Scops-owl in flight, even when it is only a meter above our head – and neither can its prey.

Humans cannot hear an Arabian Scops-owl in flight, even when it is only a meter above our head – and neither can its prey.

BREEDING BIOLOGY

Virtually nothing is known about the breeding biology of this bird. Indeed there are relatively few studies on the mating systems of owl species globally. Those that have been conducted indicate that most are socially and genetically monogamous (e.g., Ryukyu Scops-owl *O. elegans*).[160] Interestingly, both male and female Arabian Scops-owls vocalize and have been reported to occasionally duet,[161] which is usually associated with long-term monogamy and year-round territoriality.[162]

Preliminary observations suggest that Arabian Scops-owls only call during the breeding season. In Saudi Arabia individuals have been heard calling from February through to August, which suggests that this is its main breeding season. Males seem to call persistently,[163] presumably to maintain the pair bond and/or defend the nest territory. Other species of scops-owl are known

Amazingly, although an estimated 14,000 pairs of Arabian Scops-owl breed in Saudi Arabia each year, not one nest has ever been reported within the Kingdom.

Arabian Woodpeckers are master woodworkers with the remarkable ability to carve out perfect nest holes in trees using their bills.

to have overlapping territories with complex territorial defense often resulting in border fights sometimes involving both sexes (e.g., Eurasian Scops-owl;[164] Ryukyu Scops-owl[165]).

Amazingly, although an estimated 14,000 pairs of Arabian Scops-owl breed in Saudi Arabia each year, not one nest has ever been reported within the Kingdom. In fact, the only record of a nest of the Arabian Scops-owl from anywhere is a single observation of a pair at a nest hole in the Yemen highlands.[166]

Until further records become available we can only speculate that the nesting biology of Arabian Scops-owls is likely to resemble that of their nearest relatives: African Scops-owls and Eurasian Scops-owls. Both species prefer to nest in tree hollows, but will also occupy other nest sites. African Scops-owls have been recorded nesting in old woodpecker holes, and in the side of an old stick nest of the Lappet-faced Vulture. Likewise, Eurasian Scops-owls sometimes nest in a cavity in a building or wall, and readily occupy artificial nest boxes. They too occasionally use the old nests of other species, especially Eurasian Magpies or raptors, and even the disused burrows of bee-eaters. It is possible that Arabian Scops-owls are equally opportunistic and adaptable when it comes to choosing a nest site.

The nest cavities of African Scops-owl are generally between 3–5 meters above ground, but can reach 10 meters. The same nest site can be used for multiple years. African Scops-owls lay 2–4 eggs (usually 3), which hatch after 20–24 days. The female incubates the eggs and broods the hatchlings while the male provides her with food at the nest. Both parents feed the chicks. The young leave the nest after 25–28 days and continue to be fed by the parents for around 60 days. They can begin breeding within their first year.[167] Since the Arabian Scops-owl is roughly the same mass as the African Scops-owl, it is possible that their nesting phases are of similar duration. However, without direct observations, these inferences are speculative.

ARABIAN WOODPECKER: ENDEMIC TO THE ARABIAN PENINSULA.

CONSERVATION STATUS

The global population of Arabian Scops-owl is loosely estimated as 30,000 annual breeding pairs, which are restricted to Saudi Arabia, Yemen and Oman. Almost half of those birds (around 14,000 breeding pairs) occur in Saudi Arabia (*see* Table 1). It can be locally common (up to five birds have been reported calling from a single site);[168] indeed wherever it occurs it is probably the most common local owl. The IUCN lists the species as least concern due to its reasonable population size, which is spread over a large range. Unlike the Eurasian Scops-owl, which has undergone significant declines in recent decades making it the most threatened owl in Europe,[169] the Arabian Scops-owl is listed as stable in the absence of any evidence for declines or substantial threats. Arabian Scops-owls occur in good numbers in several protected areas in southwest Saudi Arabia.

ARABIAN WOODPECKER (*DENDROPICOS DORAE*)

Arabian Woodpeckers are master woodworkers with the remarkable ability to carve perfect nest holes in trees using their bills. They are also very attractive. The male is particularly striking with its crimson hindcrown and splash of orange-red feathers in the center of its belly. The black and white wings provide a neat contrast to the olive-grey-brown body, which is sometimes tinged with gold.

Unfortunately Arabian Woodpeckers are virtually unstudied. Indeed, Arabian Woodpeckers are so poorly studied that the only published measurements for this species are from a single male captured near Tanumah in 2016 by some of the authors of this book. The bird, a male, weighed 41.5 g.[170] This is a pity because other species of woodpecker that have been studied in depth in other parts of the world have proven to be immensely interesting, leading fascinating and complex lives that continue to amaze researchers following decades of study.[171]

The Arabian Woodpecker belongs to the Picidae family, known simply as the woodpeckers. Around 220 species of true woodpecker exist throughout the Americas, Europe, Africa and much of Asia, making them one of the most diverse and widespread families of non-passerine

THE ARABIAN WOODPECKER IS USUALLY FOUND AROUND 1,000–2,500 M ABOVE SEA LEVEL IN THE MOUNTAINS SOUTH FROM AL-'ULA.

birds on the planet. The Arabian Woodpecker is the only species of true woodpecker found in Arabia. It belongs to the genus *Dendropicos*, which contains 16 species occurring throughout much of Africa, as well as the Arabian Woodpecker, which is restricted to the western highlands of Saudi Arabia and Yemen.

HABITAT

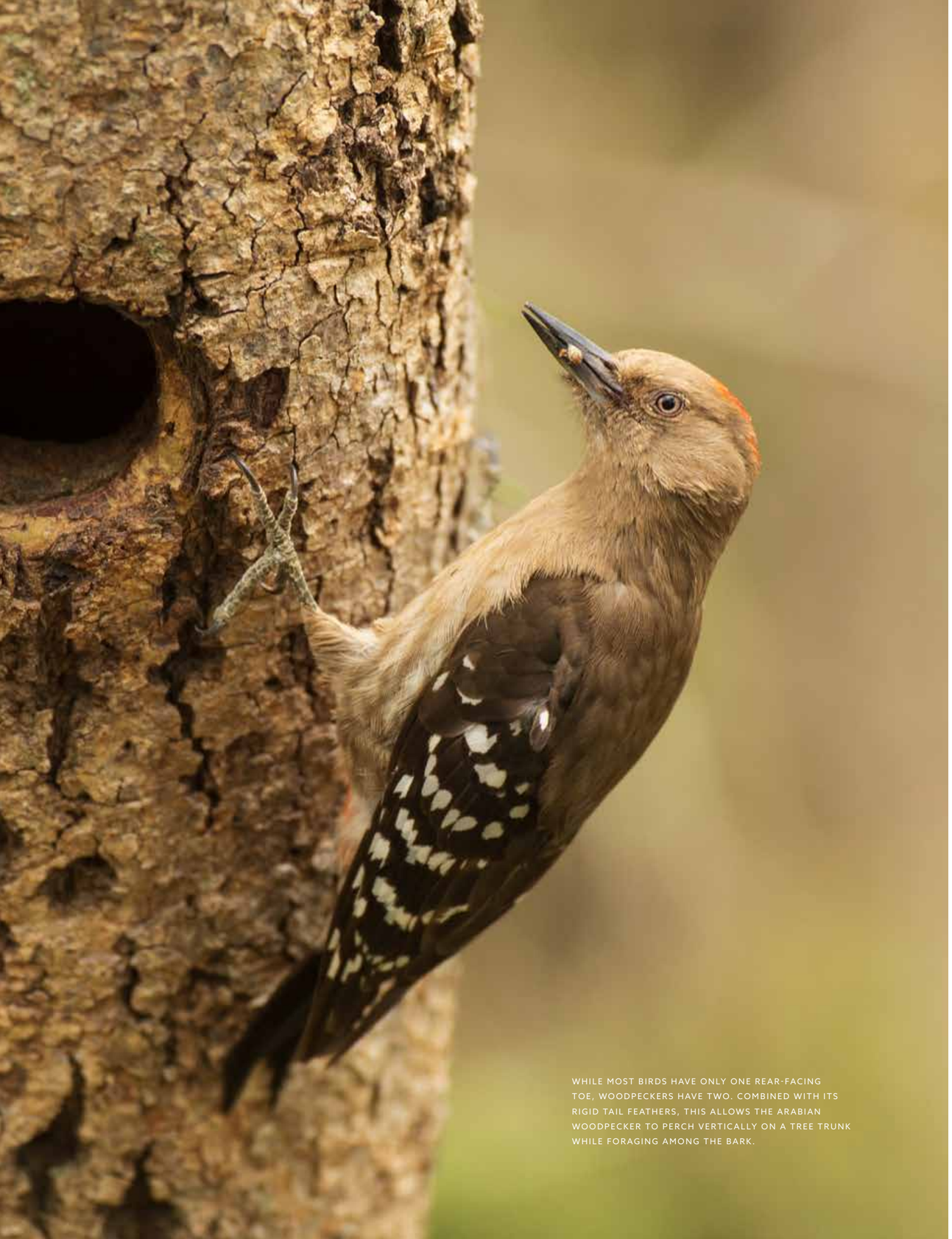
In Saudi Arabia, Arabian Woodpeckers occur from around al-'Ula (26°N) south to Yemen, from near sea level up to 2,800 meters, though it is more common between 1,000–2,500 meters. While it has been observed entering cavities as low as 400 meters, it is unclear whether these were used for nesting or roosting.[172] It seems to be more abundant on the drier, acacia-rich eastern slopes of the southwest highlands compared to the wetter western escarpment.[173] This truly fascinating bird inhabits a wide variety of woodland types, ranging from very open to quite dense forest, provided the woodland contains at least some acacias. It is often found in well-vegetated wadis dominated by cordia trees, on mountain slopes and summits containing either mixed or dense stands of predominantly juniper, olive and nuxia (often on slopes terraced for agriculture), at the base of escarpments containing date palm, fig or pandanus groves, and in Tihamah scrub and flat desert areas containing scattered acacias. It can also be found foraging in other tree species, including Ziziphus, fig, maerua, and tamarix and, less often, perching on juniper.[174] There are some indications of altitudinal migration, with birds shifting to lower elevations in winter.[175]

FORAGING ECOLOGY

Like most woodpeckers, the diet of Arabian Woodpeckers consists primarily of adult and larval insects and other arthropods taken from either living or dead trees. These may be obtained either by gleaning prey from bark or, more famously, by hammering holes into the wood to excavate wood-boring insects. The bird uses its exceptionally long and highly specialized sticky, bristled tongue to extract prey from crevices and holes.[176] It forages primarily on the main trunk but also on outer branches. In Yemen, the species has been recorded feeding on the ground, particularly around the base of sorghum plants, and it is possible that ants at the base of acacia are also taken.[177]

The ability to excavate holes in living trees not only allows Arabian Woodpeckers to access boring insects, it also allows access to rising sugary sap that lies just below the bark. Sap is an

ARABIAN WOODPECKERS USE THEIR POWERFUL BEAKS TO DRILL HOLES IN WOOD TO EXCAVATE WOOD-BORING INSECTS AND GRUBS AND TO BUILD THEIR NESTS.



WHILE MOST BIRDS HAVE ONLY ONE REAR-FACING TOE, WOODPECKERS HAVE TWO. COMBINED WITH ITS RIGID TAIL FEATHERS, THIS ALLOWS THE ARABIAN WOODPECKER TO PERCH VERTICALLY ON A TREE TRUNK WHILE FORAGING AMONG THE BARK.

important source of food for several woodpecker species and may be a significant component of the diet of Arabian Woodpeckers, particularly prior to breeding.[178] Some woodpeckers excavate small holes (called sap wells) in tree bark where they repeatedly feed on exuding sap. Similar marks have been found in the trunks of living acacia trees, but Arabian Woodpeckers have not yet been observed using the sap wells.[179]

The diet of the Arabian Woodpecker seems to vary throughout the year, perhaps depending on breeding cycle and local food availability. During the breeding season (March through June) when local acacias usually contain fresh leaves, Arabian Woodpeckers glean for surface insects and their larvae amongst the foliage. Conversely, outside of the breeding season the main foraging mode is vigorous hammering for wood-boring insects, supplemented with sap sucking on acacias.[180]

Arabian Woodpeckers probably play an important role in the ecosystem. For example, by removing large numbers of wood-boring insects and their larvae, Arabian Woodpeckers could help suppress insect irruptions and thereby keep trees healthy. Similar impacts have been well demonstrated in other woodpecker species. In North America, woodpeckers were more likely to forage on trees containing larvae Emerald Ash Borer (*Agrilus planipennis*) and removed up to 95% of borer larvae from individual trees.[181] In addition, Arabian Woodpeckers may contribute to the mechanical degradation of wood. By moving from tree to tree, woodpeckers carry beneficial fungi on their bills and bodies that ultimately help the bird to excavate holes by softening the wood. In turn, the woodpeckers help the fungus to disperse and colonize new trees.[182] The woodpeckers and fungi combine to help break down wood, thereby returning nutrients to the soil.[183]

The extraordinary ability to excavate holes in tree trunks requires a suite of specialized adaptations. First, woodpeckers must be able to stand upright against a vertical trunk for extended lengths of time. To achieve this, woodpeckers have an unusual foot structure: while most other birds have three toes facing forward and one facing back, woodpeckers have only two toes facing forward while the first and fourth toes face backward. Furthermore, the central tail feathers are particularly stiff and can be used to prop up the bird against the tree trunk, almost as if it is sitting on an in-built stool. The two backward facing toes and the stiff tail help to stabilize the bird on the vertical trunks of trees, helping it to seemingly defy gravity. Indeed, Arabian Woodpeckers are so adept at clinging to trees that they can feed perched upright or hanging upside down.

Second, woodpeckers must be able to physically carve out hollows in the hard wood of tree trunks. To achieve this, it repeatedly and forcefully thrusts its stout, sharply pointed, chisel-like beak into the wood incredibly quickly – around 20 times per second with each thrust taking only 8–25 milliseconds. An individual bird will spend many hours each day pecking for food or digging cavities, striking its bill against a tree up to 12,000 times per day. The power to chip into the wood is obtained by contracting the strong muscles in its powerful, relatively short legs and thick neck,[184] which allows the bird to impart great force against the tree.

The woodpecker repeatedly and forcefully thrusts its chisel-like beak into the wood incredibly quickly – around 20 times per second – striking its bill against a tree up to 12,000 times per day.

Woodpeckers have some superb adaptations for overcoming the hazards of smashing the beak into tree trunks and chipping away at wood. For instance, woodpeckers have an extra eyelid that closes a millisecond before each strike to shield the eye from tiny woodchips and to prevent the retina from tearing. Likewise, the nostrils are simply thin slits covered by special feathers, again to protect against flying debris.[185]

Moreover, each blow of the woodpecker's beak against the tree is equivalent to striking a wall, face-first, at 25 kilometers per hour and results in deceleration forces (of about 1200 grams) hundreds of times more intense than astronauts endure.[186] Such impacts would undoubtedly cause terrible brain trauma in humans. However, woodpeckers have a host of adaptations to prevent such injury. First, while the bill is obviously very strong, it also contains spongy bone on the upper surface to absorb some of the mechanical stress of pecking.[187] Similarly, the woodpecker's skull is made of compressible sponge-like bone (which absorbs impact) that is particularly dense around the forehead and the back of the skull where most of the impact is felt. Further, the brain is surrounded by very little cerebrospinal fluid and is unusually oriented to maximize the area of contact with the skull, which minimizes movement of the brain inside the skull while pecking and thus prevents potential brain injury.[188] The extraordinary adaptations of the woodpecker's skull has inspired engineers to develop similar shock absorbers that resist high-g forces in micro-devices, car bumpers and athletic helmets.[189]

Each blow of the woodpecker's beak against a tree is equivalent to striking a wall face-first at 25 kilometers per hour and results in deceleration forces hundreds of times more intense than astronauts endure.

BREEDING BIOLOGY

Arabian Woodpeckers are resident, pair-nesting birds. They use both vocal and non-vocal methods of advertising their presence and attracting a mate. First, both males and females give a rapid rattling call of between 7–20 notes, which is much

Only three Arabian Woodpecker nests have ever been studied.

more common in spring[190] suggesting it probably functions in sexual selection and/or defense of the breeding territory. Furthermore, like all woodpecker species, Arabian Woodpeckers can make a drumming sound by repeatedly striking their bill rapidly against a tree. These far-carrying sounds perform essentially the same function as song: they serve to define territories, attract mates and maintain pair bonds.[191] In some species, this drumming is quite dramatic and forceful, but in Arabian Woodpeckers, the drumming has been described as "rather feeble".[192]

The dual observations of slight altitudinal migration during summer and the noticeable increase in calling around the breeding season suggests that Arabian Woodpeckers do not maintain year round territories. Instead, they presumably establish new breeding territories each spring, probably in response to unpredictable food sources in Saudi Arabia's dry climate. This is supported by the observation that Arabian Woodpeckers rarely use nest holes from previous years.[193]

Once the pair has formed and a breeding territory has been established, a new nest is excavated primarily (if not entirely) by the male. Acacias (either living or dead) are the preferred nest tree, though they also nest in juniper at higher altitudes and in some softwood species. Most nest holes are carved into the main trunk. Nest holes are built generally between 2–5 meters above ground, though they have been observed as low as 20 centimeters and as high as 25 meters. Based on measurements at 14 nests, the nest is built in a trunk or limb around 25 centimeters wide; the nest entrance is 4.4 centimeters wide and 4.3 centimeters high. The nest cavity is usually 25–30 centimeters deep and situated below the nest entrance. The pair does not attempt to line the nest. Instead, the eggs are laid directly onto fine wood chippings that accumulated during nest excavation.[194]

Only three Arabian Woodpecker nest attempts have been closely followed. Based on these very limited data, it appears that three eggs are laid over three days. The eggs are incubated for only 11 days before they hatch[195] – such short incubation periods are characteristic of all woodpeckers.[196] Both parents feed and tend to the nestlings. The young birds leave the nest after 16–22 days and remain nearby for two months after fledging.[197]

Arabian Woodpeckers are ecosystem engineers: that is, by excavating holes in trees they provide cavities to a broad range of vertebrate and invertebrate species that are unable to build cavities themselves.[198] For example, the old nests of Arabian Woodpeckers are readily used by

ARABIAN WOODPECKERS DRILL HOLES IN TREES IN WHICH TO NEST. THE RED-HEADED MALE DOES MOST OR ALL OF THE NEST BUILDING .

HOUSE SPARROWS AND VIOLET-BACKED STARLINGS (NEXT PAGE) OFTEN USE THE ABANDONED NEST HOLES OF ARABIAN WOODPECKERS AS NEST SITES.

A PAIR OF VIOLET-BACKED STARLINGS USING AN ARABIAN WOODPECKER NEST.

other hole nesting birds, such as Violet-backed Starlings and House Sparrows.[199] In fact, the holes excavated by Arabian Woodpeckers are so valuable that Violet-backed Starlings will forcibly evict woodpeckers from their newly excavated nests. A decrease in the abundance of Arabian Woodpeckers would likely have a cascading effect on the abundance of these and other cavity-nesting species, further underlining the conservation value of this endemic bird.

CONSERVATION STATUS

Only around 7,500 pairs of Arabian Woodpeckers exist in the world, making it one of the rarest woodpeckers on the planet. Indeed, only five woodpecker species have fewer individuals, including two species that are probably extinct. Around three quarters of the entire global population occurs in Saudi Arabia, while the rest occur in fragmented habitat in Yemen (*see* Table 1). The IUCN lists the species as near threatened due to the small population size that is restricted to one subpopulation, and decreasing as a result of habitat loss and habitat degradation due to excessive harvesting of trees for firewood and fodder. Fortunately the species occurs in at least two protected areas in Saudi Arabia, at Rayda Reserve and 'Asir National Park.

YEMEN WARBLER (*SYLVIA BURYI*)

This sooty-grey warbler with sparkling blue or white eyes is one of the most secretive birds in Saudi Arabia. Its skulking, inconspicuous behavior renders it almost invisible in the landscape. Instead, these unassuming little birds usually reveal their presence through their endearing song.

Yemen Warblers belong to the Sylviidae family (otherwise known as the Old World Warblers and Parrotbills), which contains 22 genera and 71 species. The taxonomy of the various warbler families

YEMEN WARBLER: ENDEMIC TO THE ARABIAN PENINSULA

THE YEMEN WARBLER IS USUALLY FOUND ABOVE 2450 M IN THE 'ASIR MOUNTAINS FROM AL-BAHAH SOUTH TO YEMEN.

The sooty-grey Yemen Warbler with sparkly eyes is one of the most secretive birds in Saudi Arabia. Fortunately, these unassuming little birds reveal their presence through their endearing song.

has undergone several revisions as a result of ever-improving genetic analyses. Thus the Yemen Warbler, which was previously placed rather tentatively in other genera (including *Parisoma* and *Curruca*), is now placed confidently in the genus *Sylvia* along with 29 other species. The *Sylvia* warblers can be placed into two broad categories: migratory (and often sexually dimorphic) species that nest in Eurasia, and sedentary, monomorphic species that nest in Africa and Arabia, including the Yemen Warbler. Only one of the 30 *Sylvia* warblers is at any risk of extinction: the Yemen Warbler, which is confined to southwestern Saudi Arabia and western Yemen.

HABITAT

In Saudi Arabia, the Yemen Warbler is patchily distributed in the southwest highlands from about 19°30'N (near al-Bahah) south to Yemen. It is usually found above 2,450 meters, but has been recorded as low 1,540 meters. It prefers near-pristine highland environments (which are becoming increasingly rare) containing thick vegetation cover and dense undergrowth. It is usually found in areas of juniper forest containing a mixture of acacia and other deciduous trees. (In Yemen it can also be found in thickets of pure acacia, dense bushes in wadi basins, hedgerows near cultivated fields and thick plantations, though this does not appear to be the case in Saudi Arabia). It always occurs near available water and therefore is absent from the drier eastern fringe of the highlands. It avoids villages or other inhabited areas.[200] Yemen Warblers are sedentary residents generally found in very small numbers.

FORAGING ECOLOGY

Very little is known about the foraging ecology of the Yemen Warbler. The few casual observations of this diminutive bird suggest it probably exhibits the typical *Sylvia* warbler diet, which consists primarily of small invertebrates supplemented seasonally with some fruit, berries and a variety of seeds.[201]

The Yemen Warbler's small, slender bill, which is only 4 millimeters deep, 5 millimeters wide and less than 20 millimeters long (bill to skull)[202], suggests it focuses on small food items. However, looks can sometimes be deceiving: the closely related Brown Warbler (*S. lugens*) in eastern Africa occasionally takes caterpillars up to five times the length of its bill, pounding its prey against a perch and squashing it between its mandibles in order to remove the gut contents.[203] Likewise, the Yemen Warbler has been recorded at least once eating a surprisingly large insect as well as fairly sizeable caterpillars.[204]

The Yemen Warbler usually forages by searching among leaves and branches, often close to the main trunk of large trees. It is well adapted for foraging in acacias, where it can use its long, slender bill to probe into crevices and under bark to extract small insects, occasionally hanging upside down to pick food items from beneath leaves. It usually spends 1–3 minutes gleaning prey from a tree before flying low with noisy whirring wings to feed at the next tree.[205] It occasionally drops to the ground to forage, though rarely in the open, and may also fly repeatedly from a perch to take food items from a neighboring tree.[206]

Like most sedentary warblers, Yemen Warblers usually forage solitarily or in pairs. Several members of the warbler family join mixed-species foraging flocks (especially outside the breeding season) presumably to reduce their predation risk, though it is unknown if Yemen Warblers do likewise.

BREEDING BIOLOGY

Yemen Warblers appear to form socially monogamous pairs that probably remain together for most or all of the year. There is no information about courtship behavior or pair formation in this species, though mutual preening has been observed.[207] Interestingly, some male *Sylvia* warblers may attempt to attract females by imitating the calls of other bird species. For instance, a single male Chestnut-vented Warbler (*S. subcoerulea*) in South Africa was observed to imitate at least 29 different bird species, including migratory species that had not been in the area for five months.[208] In several bird species mimicry is used as a means of attracting females, which prefer males with a larger repertoire size.[209] Birdwatchers in the 'Asir Mountains should listen carefully to hear if Yemen Warblers likewise impersonate other species.

Like most *Sylvia* warblers, pairs of Yemen Warblers probably nest solitarily. At the onset of breeding, pairs establish and defend a relatively small territory. It is likely that males in particular begin to engage in territorial disputes involving high-intensity song contests, singing persistently from hidden perches or during song flights. The Yemen Warbler's full song is a slow rich warble given in short but quite loud bursts of around 20 seconds.[210] They may also engage in threat displays, chasing, and perhaps even combat, as recorded in several other closely related species. An interesting feature of *Sylvia* warblers is that these territorial battles are not confined to members of their own species – they will also engage in fierce territorial disputes with other *Sylvia* warblers.[211] Thus it is possible that Yemen Warblers fight regular territorial battles with both Brown Woodland-warblers and Arabian Warblers wherever their ranges overlap. Yemen Warblers have been observed singing their sweet high-pitched territorial song in most months,[212] not just during the breeding season. This suggests they maintain their territories throughout the year.

Many male *Sylvia* warblers build one or more "cock's nests". These are nest-like structures built to attract a female, and range from a loose platform of potential nesting material to an elaborate nest. Males that build more extravagant nests are presumably demonstrating their quality and willingness to invest in reproduction. In some cases, the female selects a cock's nest to use as the platform on which to build the actual breeding nest; in other cases, a new breeding nest is built from scratch.[213]

Of the handful of Yemen Warbler nests that have been discovered, most were located only 0.2–1.5 m above ground in dense ground cover, a bush or clump of brambles. However, one nest was built about 4.5 m above ground high up in a juniper tree. The nest consists of a flimsy cup made of fine twigs, grass, rootlets and lichen, and is very lightly lined with fine rootlets and some hair. Some Yemen Warbler nests are attached to, and partially screened by, trailing lichen.[214] Based on the behavior of many well-studied *Sylvia* warblers, it is likely that both parents are involved in nest building, though the female may contribute more.[215]

In eight non-migratory *Sylvia* warblers from Africa, clutch size is only 2–3 eggs.[216] Accordingly, the only clutch ever reported in the Yemen Warbler (which was found near the summit of

Birdwatchers in the 'Asir Mountains should listen carefully to hear if Yemen Warblers impersonate other species. Closely related warblers have been recorded imitating the calls of at least 29 different bird species.

YEMEN WARBLERS FORAGE FOR SMALL INSECTS AMONGST LEAVES AND BRANCHES, USUALLY CLOSE TO THE MAIN TRUNK OF THE TREE.

VERY LITTLE IS KNOWN ABOUT THE SPARKLY-EYED YEMEN WARBLER.

Ringing studies indicate that even tiny warblers can live for a surprisingly long time, with several species living for 7–13 years in the wild and one living for 18 years in captivity.

To reduce their risk of predation, Yemen Warblers possess no ornamentation in their plumage, skulk in bushes, and build cryptic nests tucked inside dense vegetation.

Rayda Reserve) consisted of two eggs, which were smooth and glossy-white with various brown blotches.[217] In all *Sylvia* warblers in which parental roles have been reported (n=18) both parents incubate the eggs, though the female performs the majority of the task in at least some of these species. For example, female Dartford Warblers (*S. undata*) perform two-thirds of incubation during the day and all of the incubation at night.[218]

Incubation duration is unknown for Yemen Warblers, but is likely to take around 14–16 days (based on sedentary *Sylvia* warbler species nesting in Africa).[219] Chicks at one observed Yemen Warbler nest hatched synchronously, which implies that incubation begins only after the clutch has been completed. Based on a sample of four Yemen Warbler nests, brood size ranges from 1–3 (again indicative of a small clutch), and both parents feed the young.[220] The duration of the nestling period is unknown, but in sedentary African *Sylvia* warblers it is 14–15 days.[221] Using the behavior of closely related African warblers as a guide, both parents are likely to continue feeding the young after they have left the nest until they achieve foraging independence sometime between 5–8 weeks later. Even once feeding has ceased, the young birds may remain in the parent's breeding territory for several weeks until eventually dispersing.[222] In *Sylvia* warblers the young are usually capable of breeding the year after they hatched, at which time they are around 9–10 months old.[223]

Ringing studies have revealed that these tiny birds can live for a surprisingly long time. Seven species of *Sylvia* warblers have been recorded living for between 7–13 years in the wild, while the oldest known Garden Warbler lived for over 18 years in captivity, suggesting that such longevity may not be uncommon for the genus.[224]

As a rule, warblers suffer high levels of nest predation. Based on predation reports from other species of *Sylvia* warblers, the list of potential nest predators for the Yemen Warbler is very long, and could include Asir Magpies, goshawks, shrikes, foxes, cats, dogs, snakes, and many other species. To reduce their risk of predation, Yemen Warblers possess no ornamentation in their plumage, skulk in bushes, and build cryptic nests tucked inside dense vegetation. Nonetheless, predators may still be able to detect the presence of the nest by observing adult birds carrying food items repeatedly into one particular bush. Thus, another way that birds can minimize the risk of predation is by reducing their nest visitation rates.[225] A study of Brown Warblers (*S. lugens*) and Banded Warblers (*S. boehmi*) from Kenya (both closely related to Yemen Warblers) revealed that both species suffer from high rates of nest predation with 67% and 81% of nests failing, respectively.[226] Conversely, parental activity at the nest is very low: an adult would arrive at the nest only once every 30 minutes during the incubation period. Even at the height of chick hunger, parents would feed the chicks less than once every 5 minutes.[227] As a comparison, other *Sylvia* warblers nesting in areas that experience lower levels of nest predation feed their chicks between 2–5 times more often at the point of peak demand.[228] The low nest visitation rate of African *Sylvia* warblers comes at the cost of raising fewer chicks per nest attempt: more chicks would obviously require more food, but bringing more food to the nest is simply too risky. Thus, the small clutch size of Yemen Warblers may well be an adaptation to high predation rates and low food availability in the arid environment of the 'Asir Mountains.

Another way to mitigate the high rates of nest predation experienced by *Sylvia* warblers is to lay several small clutches each season, thereby diluting the impact on annual reproductive success if one nest is lost to predation. Accordingly, both the Brown Warbler and the Banded Warbler lay an average of 3.7 clutches per year, with each clutch containing an average of two eggs.[229] Such multi-brooding is a common feature of *Sylvia* warblers and is likely to occur in Yemen Warblers. In addition, warbler chicks leave the nest before they are capable of proper flight, which may further reduce the risk of nest predation by allowing the parents to gradually move the chicks to a new location, ideally away from the prying eyes of marauding nest predators.

Yemen Warblers might also be vulnerable to nest parasitism by cuckoos as has been reported in several other *Sylvia* warblers. Common Cuckoo and Jacobin Cuckoo have been reported to parasitize the nests of Garden Warblers, Common Whitethroats and Chestnut-vented Warblers, while Jacobin Cuckoos occasionally parasitize the nests of other similar sized warblers in Africa.[230]

CONSERVATION STATUS

Only 9,000 pairs of Yemen Warbler are estimated to exist in the world. More than half of the population nests in southwestern Saudi Arabia while the rest occur in western Yemen (*see* Table 1). The IUCN lists the species as near threatened on account of its small population size and reduced range. Its furtive habits make it difficult to find though it can be locally common, particularly in high quality habitat between Tanumah and Jabal Sawda' (a distance of only 80 kilometers). Furthermore, the species is listed as decreasing due to ongoing deforestation and degradation of its montane woodland habitat through agricultural intensification, residential and recreational development for a rapidly increasing human population, and unsustainable use of forest resources for animal fodder, fuel, and building material.[231] In short, the Yemen Warbler is the most rare and most threatened *Sylvia* warbler on earth. Fortunately the species occurs in at least two protected areas in Saudi Arabia: Rayda Reserve and 'Asir National Park.

YEMEN THRUSH: ENDEMIC TO THE ARABIAN PENINSULA.

YEMEN THRUSH (*TURDUS MENACHENSIS*)

The thrush family includes some of the most well studied birds on earth, including the Eurasian Blackbird (*T. merula*), Song Thrush (*T. philomelos*), and American Robin (*T. migratorius*), and in each case, these birds have been found to lead extremely interesting and complex lives, particularly with respect to their breeding behavior, social interactions and exquisite songs. Unfortunately, there have been literally no detailed studies of the Yemen Thrush. This is a pity because there is no doubt that detailed studies of Yemen Thrush would reveal equally fascinating adaptations to life in the highlands of southwest Arabia. It is also a concern – only an estimated 10,000 breeding pairs are left on the planet, and studies are needed to determine how best to conserve this vulnerable endemic species.

The Yemen Thrush belongs to the Turdidae family (known simply as the thrushes), which is a large family containing 339 species from 60 genera. The genus that the Yemen Thrush belongs to (*Turdus* or the so-called "True Thrush") contains 71 species from much of Eurasia, North America and Africa. The position of the Yemen Thrush within this large genus is still unclear. In a recent genetic analysis of the Thrush, it was one of only five species that was not assessed.[232] The authors were therefore unwilling to predict whether it is more closely related to Eurasian or African thrush, though (on the basis of its distribution in the far southwest) the latter seems more likely. The Yemen Thrush is the only thrush to breed in Saudi Arabia. It can be found only in southwestern Saudi Arabia and Yemen.

Thrushes are famous for their complex social behavior, their fascinating breeding behavior and their exquisite songs.

YEMEN THRUSH ARE FOUND HIGH IN THE 'ASIR MOUNTAINS SOUTH FROM AROUND TAYIF TO YEMEN.

Yemen Thrush may use large flat stones as anvils to smash open snail shells so they can eat the contents.

HABITAT

Yemen Thrushes are birds of the highlands. In Saudi Arabia they occur from just north of Tayif and south to Yemen. Although they have been recorded as low as 1,200 meters, they are found usually above 2,100 meters in all kinds of thick vegetation, especially native trees and shrubs. They occur in densely vegetated wadi basins with nearby cultivation, tree-lined terraces, thickets, orchards and overgrown gardens, but are most numerous in mixed juniper and acacia woodlands. They appear to need reliable access to water: they come to water regularly and are not found in dry wadis even only 5 kilometers east of the highland ridge. They tend to skulk or remain motionless in thick vegetation for long periods, and only occasionally venture out into adjacent open areas, such as short grass or cultivated fields.[233] The Yemen Thrush is probably a year round resident, though (as it appears scarcer in the highlands during winter) there may be some altitudinal migration in parts of its range[234] as has been recorded in several other thrush species.[235]

FORAGING ECOLOGY

The diet of Yemen Thrush has not been studied in detail. Nonetheless, it appears to have the classic thrush ecological flexibility that enables individuals to switch between terrestrial invertebrates and fruit (including juniper, Rosehips, wild olive and Figs). It will also eat exotic and introduced species in gardens.[236] In most thrush species, especially those inhabiting temperate environments, invertebrates are preferred during the spring and summer, while fruit becomes increasingly important from late summer until late winter.[237]

It forages mainly on the ground, typically amongst bushes and undergrowth, often tossing leaf litter and debris aside with a rapid flick of the head as it searches for invertebrate prey.[238] It has been recorded eating snails and, like several other thrushes,[239] may use large flat stones as "anvils" to smash the snail shells upon. Although this behavior has not been directly observed in Yemen Thrush, collections of broken snail shells have been found on anvils in Yemen Thrush habitat[240] (although it is conceivable that the anvils were used by wintering Song Thrush, which are also known to use anvils, including in the nearby Negev Desert[241]).

BREEDING BIOLOGY

There is no published information about Yemen Thrush courtship behavior; and courtship behavior is so variable within the thrush family that it is not possible to predict what Yemen Thrush courtship might consist of. Certainly one feature of Yemen Thrush that stands out as being a likely candidate for use in mate attraction is the yellow bill, which varies in brightness between individuals. Experiments in the closely related Eurasian Blackbird have demonstrated that when the bird is fighting an infectious disease the bill becomes significantly less brightly colored within a matter of days.[242] This is because birds are unable to manufacture the carotenoid pigmentation required to produce such yellow coloration; instead they must consume carotenoids in their diet. Carotenoids not only produce yellow pigmentation, they are also antioxidants that are used in fighting infectious diseases. Thus, when birds are struggling with an infectious disease, the immune system is activated and carotenoids are redirected from the plumage into the blood stream. Hence it is very likely that a Yemen Thrush with a bright yellow bill is a high quality bird with a good immune system, which is obviously attractive to potential mates.

Unlike courtship behavior, territorial behavior is fairly consistent amongst the thrushes: almost all non-migratory thrushes form socially monogamous pairs that maintain year-round territories

YEMEN THRUSH FORAGE ON A MIXTURE OF INVERTEBRATES AND FRUIT.

THE BRIGHT YELLOW BILL AND LEGS OF THE YEMEN THRUSH SIGNALS ITS HEALTH STATUS.

in which the sexes perform very specific roles. In most thrushes, the male establishes the territory and then the female finds and bonds with him.[243] Preliminary observations suggest this is the case for Yemen Thrush.[244] In Yemen Thrushes, only the male sings, which implies that establishing and maintaining the territory is the sole domain of the male. The bird perches atop a high and exposed branch – especially at dawn – and bursts forth with a series of fluty, high-pitched phrases. Most singing occurs from March to June[245] – that is, during the early part of the breeding season – which further suggests the male Yemen Thrush is using song to establish a breeding territory and to attract or maintain a mate.

In most thrushes, the male devotes the majority of his time to patrolling and defending the territory, while the female builds the nest and incubates the eggs; both parents feed and tend the offspring.[246] Again, the Yemen Thrush appears to follow this broad mating system. The female alone is responsible for building the nest: a firm cup of grass, small twigs, moss and thin strips of bark, sometimes with paper and moss around the rim. The interior of the nest is lined with a layer of mud, which in turn is lined by fine grasses, occasionally intermixed with slender rootlets. The nest is rather small for a bird of its size: the outer diameter of the nest is only 15 centimeters, while the inner cup is 9 centimeters.[247] The mud lining of the inner cup is interesting: it may enhance nestling survival by creating conditions inside the nest that are unsuitable for insect parasites (as has recently been suggested for the similar mud lining in the nest of the Song Thrush).[248]

Of the few Yemen Thrush nests reported in the literature, most have been built in the fork of a tree or bush from 1.5–4 meters above ground and usually concealed within overhanging vegetation, such as the beard-like Hanging Tree Lichen, which grows profusely from juniper trees across much of the southwest highlands. Most nests have been found in juniper trees, while others have been found in *Euphorbia*, an exotic *Cypressa* tree, or in one instance hidden in ferns and herbs in a stone wall shaded by bushes and surrounding a terraced field;[249] the latter nest suggests the species has quite versatile nesting behavior.

It seems that the clutch of Yemen Thrush is rather small. Of the very few nests examined, most had two eggs, and on one occasion the clutch contained only a single egg. A clutch of three eggs has been recorded only once, and more than three has never been recorded.[250] The small clutch may be an adaptation to the arid and nutrient-poor conditions typical of the ‘Asir Mountains. There may simply be insufficient food available in the bird’s territory to reliably support a larger clutch (as has been demonstrated in other passerines living in arid environments).[251] A small clutch may also be an adaptation to particularly high nest predation rates (see below).

The Yemen Thrush lays a small clutch, which may be an adaptation to the arid, nutrient-poor conditions of the ‘Asir Mountains.

In Yemen Thrush, the female lays her eggs over multiple days but begins incubating only after the clutch is complete.[252] Consequently, both eggs will hatch around the same time, eliminating any size hierarchy within the brood. This suggests that the female will attempt to feed her chicks equally in an effort to raise both young. (Conversely, if she were to incubate the first egg as soon as it were laid, it would hatch first thereby establishing a significant size advantage over the second hatchling, which often facilitates the death of the smaller chick, as demonstrated experimentally in other *Turdus* thrush).[253] If the female has sufficient time and energy available at the end of the nesting attempt, she is likely to lay a second clutch: virtually all studied *Turdus* thrushes are double brooded and several lay three or even four broods in a season.[254]

Yemen Thrush nesting attempts have never been followed in detail, thus the duration of the incubation and nestling phases are unknown. However, in most *Turdus* thrush the eggs take 12–14 days to hatch, and the hatchlings leave the

THE BILL OF THIS YEMEN THRUSH APPEARS DULL, WHICH SUGGESTS IT IS FIGHTING AN INFECTION.

IN YEMEN THRUSH, THE FEMALE BUILDS THE NEST IN A CONCEALED LOCATION. SHE INCUBATES THE EGGS WHILE THE MALE DEFENDS THE TERRITORY. BOTH PARENTS FEED THE CHICKS.

The Yemen Thrush strategy of nesting within hanging lichen allows the nesting bird to see through the wispy lichen tendrils while at the same time making it difficult for passing predators to detect the nest.

nest 13–15 days later.[255] In Yemen Thrush, both adults feed the nestlings and fledglings and defend the nest through alarm calling.[256] In most thrushes, the males deliver the majority of the food consumed by the nestlings while the female performs all of the brooding. The young of cup-nesting thrushes often leave the nest before they are able to fly, and continue to be fed by both parents for around 12–21 days.[257] During this time, the flightless "semi-fledged" young are obviously very susceptible to ground predators.

Predation of eggs and chicks is the major cause of nest failure among thrushes globally. In Eurasian Blackbirds, for example, nests have a 5% chance of being attacked by a predator every single day, meaning that the majority of nesting attempts are destroyed before the chicks have fledged.[258] Ravens and magpies are known to be significant predators of thrush nests[259] and Brown-necked Ravens, Fan-tailed Ravens and Asir Magpies would probably prey on the nests of Yemen Thrush, along with predatory mammals such as rats and cats.

To dilute the impacts of nest predation, most thrush species produce multiple broods in a season. Nest failure in thrushes almost always results in a change of nest site and fairly commonly in divorce. In Eurasian Blackbirds, for example, the annual rate of divorce varied from 5–19% in one study population and exceeded 50% in another.[260] High rates of nest predation, relocation and divorce are likely to be the case for the Yemen Thrush as well.

The high level of nest predation among the thrushes has selected for small, cryptic nests – even at the expense of chick health. Experiments in thrush species have demonstrated that even though a larger nest would improve nestling growth and health,[261] thrushes build smaller nests because these are less vulnerable to predation.[262]

Given that high levels of nest predation have exerted strong selection pressure to build small, cryptic nests, it seems odd that the eggs of thrush are blue and rather conspicuous. The eggs of Yemen Thrush, for instance, are pale blue with variable reddish-brown spots and blotches.[263] In species like Yemen Thrush with open cup-shaped nests these seemingly conspicuous eggs will be repeatedly exposed to potential predators (e.g., during most of the egg laying period and whenever the female is foraging during the 12–14 day incubation period). However the ambient light at thrush nests is predominantly yellow, which means that blue eggs appear almost black when viewed in their nest.[264] Experiments have demonstrated that the sky-blue eggs of thrushes do not increase nest predation rates.[265] Thus, the mottled blue eggs of Yemen Thrushes might actually be difficult to detect in the filtered light environment of their nest sites.

Further, experiments in thrushes have demonstrated that the specific placement of the nest appears to be more important than egg coloration, presumably because nest predators are searching for *nests* not *eggs* per se.[266] Experiments on Song Thrushes have demonstrated that the females attempt to select a nest site that provides the best trade-off between a completely concealed nest and a nest that allows the sitting bird a view of its surroundings (thereby allowing the sitting bird to escape if it detects an approaching predator).[267] The Yemen Thrush strategy of nesting within hanging lichen is probably very sensible as it would allow the nesting bird to see through and around the wispy lichen tendrils while at the same time making it difficult for passing predators to detect the nest (in much the same way that it is easier to see out through a sheer veil than it is to see into one).

BUFF-BREASTED WHEATEAR: ENDEMIC TO THE ARABIAN PENINSULA.

BUFF-BREASTED WHEATEAR (*OENANTHE BOTTAE*)

Buff-breasted Wheatears have only recently been recognized as a distinct species endemic to Saudi Arabia and Yemen. In previous taxonomic systems, the Buff-breasted Wheatear was often considered to be a subspecies of Rusty-breasted Wheatear (*O. frenata*), which occurs in Eritrea and Ethiopia. In others, it was regarded as a sedentary subspecies of the otherwise migratory Isabelline Wheatear (*O. isabellina*), which nests across western and central Asia before migrating south to spend the winter in Africa, Arabia and India. In yet other taxonomies, it was regarded as a subspecies of Hueglin's Wheatear (*O. hueglini*), which nests across the arid Sahel Zone from West Africa to Sudan. However, recent analyses and multiple revisions of wheatear taxonomy indicate that the Buff-breasted Wheatear of Arabia is a distinct species unto itself. The main reasons for separating the Buff-breasted Wheatear from all other wheatears include the abrupt geographical break between them, as well as differences in size, plumage, habitat and perhaps behavior.[271] The taxonomy of the wheatears is far from settled and future genetic analyses could conceivably result in further revisions of this group of quite stylish birds.

Buff-breasted Wheatears belong to the Muscicapidae family (known as the Old World Flycatchers and Chats), which contains 335 species from 56 genera. The genus containing Buff-breasted Wheatear (*Oenanthe*) contains 28 species, which are mostly sedentary residents across Africa, Arabia, the Middle East and India, with some migratory species nesting in Eurasia. The Buff-breasted Wheatear is endemic to Arabia, occurring only in southwestern Saudi Arabia and western Yemen.

Buff-breasted Wheatears have only recently been recognized as a distinct species endemic to Saudi Arabia and Yemen.

CONSERVATION STATUS

Only 10,000 pairs of Yemen Thrush are estimated to exist in the world, with half the population in southwestern Saudi Arabia and the rest in western Yemen (*see* Table 1), making it one of the five rarest thrush species on earth.[268] When suitable habitat can be found, it can be rather common. For instance, Yemen Thrush are one of the most numerous birds on Jabal Sawda' in the 'Asir; but unfortunately they do not seem to be as abundant anywhere else.[269] The IUCN lists the species as near threatened on account of the small population size and decreasing due to the continued loss and degradation of its montane woodland habitat through land clearing for recreational, residential and agricultural development, excessive tree lopping for firewood, dam development and high levels of grazing and browsing by livestock.[270] Consequently, much of its former range now contains unsuitable habitat. Fortunately, it can occur in fragmented woodland areas close to human habitation. Further, it inhabits at least two protected areas in Saudi Arabia: Rayda Reserve and 'Asir National Park.

THE BUFF-BREASTED WHEATEAR OCCURS IN THE 'ASIR MOUNTAINS SOUTH FROM TAYIF USUALLY IN AREAS ABOVE 2300 M.

HABITAT

In Saudi Arabia, the Buff-breasted Wheatear occurs from near Tayif south to Yemen. It is usually found above 2,300 meters, though some have been recorded nesting as low as 1,700 meters. It appears to occur within a fairly narrow range of habitats, preferring flat or slightly sloping open country with sparse vegetation, such as cultivated terraced fields (whether they contain crops or stubble or are fallow) and stony plateaus with scattered bushes. It particularly favors cultivated fields with nearby banks or walls containing crevices suitable for nesting. It avoids thick scrub and woodlands. Buff-breasted Wheatears are largely sedentary though some individuals move to considerably lower altitudes during winter with birds recorded below 200 m in the Tihamah.[272]

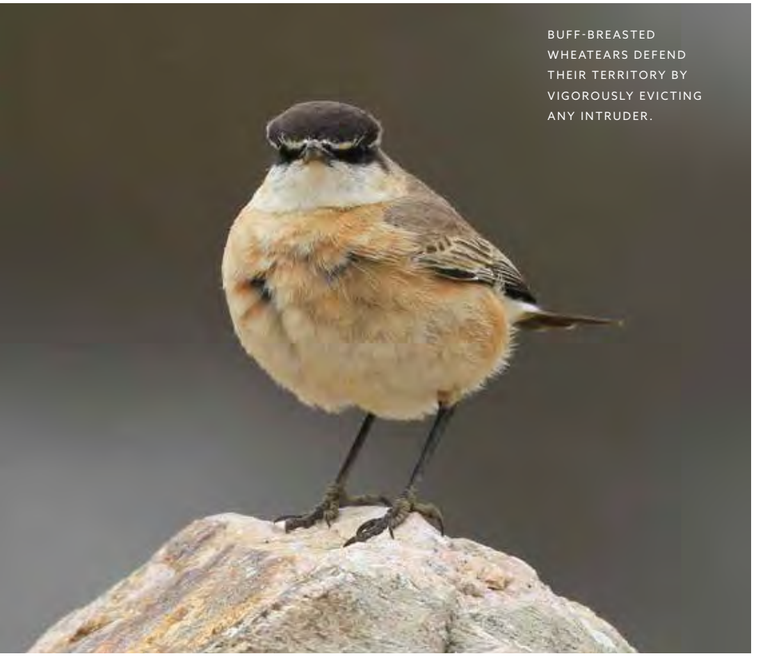
FORAGING ECOLOGY

There is very little information about the foraging ecology of the Buff-breasted Wheatear. Individuals have been seen to take insects and feed its young with large grubs.[273] The diet is presumably similar to other *Oenanthe* wheatears, particularly sedentary species within arid regions in Africa and the Middle East, all of which prey upon a very wide array of adult and larval arthropods, with ants and beetles being especially common. Most insects consumed by wheatears are less than 10 millimeters in length, though some may occasionally exceed 40 millimeters. Prey species include both terrestrial and aerial invertebrates, and occasionally small vertebrates, especially lizards up to 10 centimeters long. Further, most wheatears supplement their diet with some plant matter, including seeds and small berries (such as Arabian Boxthorn).[274]

Buff-breasted Wheatears have been observed foraging for prey by methodically searching the ground or pouncing on prey from vantage points, such as boulders and posts.[275] Most wheatears in hot arid environments forage primarily in the cooler parts of day, using a combination of bound-and-grab maneuvers, perch-and-pounce sallying, sallying after flying insects and gleaning. They may also dig into the ground when few invertebrates are available on the surface, and some also search for food inside rodent burrows.[276]

Buff-breasted Wheatears obtain most or all of their food from within year-round all-purpose territories, which they defend uncompromisingly, forcefully displacing not just other Buff-breasted Wheatears but all other species of wheatear as well, including migratory species.[277] Territoriality has been observed in all months, even during molt (in July and August) when the bird's energy

Buff-breasted Wheatears obtain most or all of their food from within year-round all-purpose territories, which they defend uncompromisingly, forcefully displacing any species of wheatear.



BUFF-BREASTED WHEATEARS DEFEND THEIR TERRITORY BY VIGOROUSLY EVICTING ANY INTRUDER.

Many young wheatears will die through their first winter, but those that survive must try to acquire a territory of their own, either by squeezing in between existing territories or by overthrowing a rival.

is sapped both by the molting process and the intense summer heat. Clearly defending the territory is extremely important to individual survival or reproduction. Territory characteristics have not been carefully measured in this species, but ten pairs were found in one 3-square-kilometer patch of cultivated fields in Yemen.[278]

The size and shape of a pair's territory is likely to be influenced by several factors.[279] First territory size and shape is impacted by the costs and benefits of territory defense. For instance, on the one hand larger territories contain more food than smaller territories (all else being equal); but on the other hand, larger territories are more energetically costly to defend since the bird must fly further to inspect and protect its boundaries. This is particularly relevant in Saudi Arabia where flight is heavily constrained by very high daytime temperatures. Accordingly, territory sizes in other sedentary wheatears in the region vary considerably depending on the local availability of resources. For example, Mourning Wheatears (*O. l. lugens*) in southern Jordan defend territories ranging from around 2 hectares to at least 45 hectares, with birds needing larger territories in more arid regions where food is less abundant.[280] Of course, food availability is not the only important resource in a territory: the area must also contain a suitable nesting site, access to water, protection from predators, and in some cases suitable perches or vantage points to scan the environment.

Territories will also be heavily impacted by the frequency and intensity of interactions with other birds. Territory size can shrink under the balance of pressure exerted by more birds along a territory boundary. For instance, when food is more abundant more competitors will be attracted to the area, making the area more costly to defend and resulting in smaller territory sizes.[281] Further, territory size may change as a result of changes in the physical abilities and relative health of competing birds over time. When one bird becomes stronger its territory size may expand as its neighbor becomes older and physically weaker (as appears to occur in White-crowned Wheatears in eastern Egypt).[282]

Not only that, territory size and shape may continually change in response to interactions with potential settlers that are attempting to acquire territories for themselves. For instance, every year thousands of young birds fledge the nest and disperse from their parents' territories in search of territories of their own, thereby flooding the already saturated landscape with more birds seeking territories. Many young wheatears will die through their first winter, but those that survive must try to acquire a territory of their own, either by squeezing in between existing territories or by overthrowing a rival. In the case of Buff-breasted Wheatears, the appearance of birds at low altitudes in winter (1,500 meters below the species' typical range) could well be young birds attempting to find food and gain strength in a vacant area free from competitors before returning to higher altitudes where they will attempt to oust a bird from its all-important territory so it can then acquire a mate of its own.

BREEDING BIOLOGY

Three lines of evidence suggest Buff-breasted Wheatears may form long-lasting pair bonds. First, they tend to be found in pairs all year round. Second, these pairs defend their territories by singing and aggressively evicting intruders. Territorial behavior intensifies during the breeding season such that pairs will chase *any* bird that comes within a few meters of the nest site, including innocuous species such as House Sparrows and Yemen Serin.[283] Such joint territoriality implies that pairs make strong and lasting bonds. Third, males and females appear similar, which again is typically associated with birds that form long-term monogamous pairs – although there are exceptions to every rule.[284]

BUFF-BREASTED WHEATEARS PROBABLY FORM LONG TERM MONOGAMOUS PAIRS.

Territorial behavior intensifies during the breeding season. Pairs will chase any bird that comes within a few meters of the nest. Even rather innocuous birds such as House Sparrows or Yemen Serin will be rudely evicted.

Courtship includes the male performing a display flight in which it flies straight up from the ground to about 3 meters then tumbles back to earth. As the breeding season commences, pairs select a hole or crevice within their territory in which to place their nest, either among rocks and boulders, in the stone walls of terraced fields, or in the old nest burrows of rodents. Both adults build the nest, which is a cup made of grass and straw and lined with feathers and placed anywhere from near the entrance to the nest cavity to 1 meter inside the cavity.[285]

Clutch characteristics and brood size are unknown. They may show similarities to the closely related Rusty-breasted Wheatear in eastern Africa, which lays 2–4 eggs that are incubated primarily or solely by the female for 14 days. Chicks leave the nest 15 days later. In Buff-breasted Wheatears both sexes feed the chicks and fledglings, which usually number 2–3 per brood. The species has a long breeding season, which suggests it is probably double brooded.[286] Young birds are likely to achieve sexual maturity in the first year. There have been few studies on the longevity of wheatears, with the oldest known wheatear reaching at least 7 years of age.

CONSERVATION STATUS

The global population of Buff-breasted Wheatears is estimated to be around 40,000 breeding pairs, around one-third of which breed in Saudi Arabia, while the rest breeds in Yemen (*see* Table 1). The species is often locally common. The IUCN lists the Buff-breasted Wheatear as least concern due to the reasonable population size, which is spread over a large range. Further, the population is suspected to be stable in the absence of evidence for any declines or substantial threats.[287] The species appears to benefit from the presence of cultivated fields, particularly in areas with traditional stone-wall terraces. Further, at least some individuals are able to tolerate significant disturbance: for instance one nest was found at ground level under a boulder only 3 meters from the edge of a busy road.[288] Buff-breasted Wheatears are found in several protected areas within the Kingdom.

THE BUFF-BREASTED WHEATEAR IS A NEWLY RECOGNIZED SPECIES. IT OCCURS ONLY IN SOUTHWESTERN SAUDI ARABIA AND WESTERN YEMEN.

ARABIAN SUNBIRD: ENDEMIC TO THE ARABIAN PENINSULA.

ARABIAN SUNBIRD (*CINNYRIS HELLMAYRI*)

Watching a male Arabian Sunbird hovering as it feeds at a flower is surely one of the sweetest pleasures in Arabian ornithology. As the bird moves in the sunlight, the bird's iridescent plumage flickers and shimmers to reveal vibrant flashes of metallic green, lustrous purple and electric blue with hints of yellow and gold. Add to this a scarlet red band across the breast and a slender, elegantly curved bill, and the male Arabian Sunbird is unquestionably one of the most beautiful birds in Saudi Arabia. The female, on the other hand, is mostly grey-brown with no apparent ornamentation whatsoever. Species with such high levels of sexual dichromatism (i.e., the males and females appear completely different from each other) usually have complex and fascinating mating systems, and this is likely to be the case for this special endemic bird.

Western Scientists first discovered sunbirds in Arabia in 1904 in the mountains north of Lahij in southern Yemen. Yet for over a century, the Arabian population of sunbirds was regarded as the same species as the Shining Sunbird that occurs throughout the Horn of Africa (from Sudan south to Somalia and west to Uganda). It was not until 2017 that scientists recognized that the African and the Arabian populations were in fact two distinct species, now known as the Shining Sunbird (*Cinnyris habessinicus*) and the Arabian Sunbird (*Cinnyris hellmayri*), respectively. Compared to the Shining Sunbird, the Arabian Sunbird is significantly larger. The male has a narrower and less bright red breastband, more extensive and deeper blue reflective upper tail-coverts, and appears to sing a different song. Further, female Arabian Sunbirds are much darker grey-brown than their African counterparts.[289] Thus, this newly recognized species is restricted to Saudi Arabia, Yemen and southwest Oman and is therefore endemic to Arabia.

Arabian Sunbirds belong to the Nectariniidae family (sunbirds), which consists of 147 species from 15 genera. The largest genus (*Cinnyris*) comprises 58 species (50 of which are scattered throughout Africa, while the rest occur from Arabia, through India to southeast Asia and northern Australia), including the Arabian Sunbird. Two subspecies of Arabian Sunbird are recognized. The majority of the Saudi Arabian population is regarded as *C. h. kinneari*, while birds in the extreme southwest (around Najran), Yemen and Oman are regarded as *C. h. hellmayri* (which has a longer bill, more metallic blue in the crown and a less defined red breastband that is partly obscured by a green-blue band).[290]

THE MAGNIFICENT ARABIAN SUNBIRD OCCURS IN THE FOOTHILLS OF THE HIJAZ AND 'ASIR MOUNTAINS SOUTH FROM AROUND KHAYBAR.

HABITAT

In Saudi Arabia, Arabian Sunbirds occur throughout much of the Hijaz and 'Asir Mountains. It has been recorded breeding as far north as 25.5°N (around Khaybar) and may occur further north still, though it is more common south of Makkah. It is found most often between 250 meters and 1,800 meters, though it has been recorded to 2,300 meters in Yemen. It prefers rocky areas and quite enclosed habitats such as hillsides and steep-sided wadis, but can exploit a range of habitats from areas of thick green vegetation (including gardens, orchards and cultivated areas) to dry scrub. It avoids open desert. It is primarily a resident species, though some birds may wander seasonally in search of flowering plants.[291]

ARABIAN SUNBIRDS ARE HIGHLY ADAPTED TO DRINKING NECTAR. THEY OFTEN PERCH AT IMPOSSIBLE ANGLES TO ACCESS THE SWEET LIQUID.

The Arabian Sunbird feeds primarily on nectar, which it obtains by perching on plants or hovering like a helicopter in front of flowers, much like a hummingbird.

FORAGING ECOLOGY

The Arabian Sunbird feeds primarily on nectar, which it obtains by perching on plants or by hovering in front of flowers, much like a hummingbird. It also eats small insects (such as ants and mites), which are typically taken from the flowers at which it is feeding, though it will occasionally hawk for aerial insects.[292] It may also consume spiders as recorded in several other sunbird species.[293] It usually feeds singly or in pairs or occasionally in small family groups, though larger clusters may gather at particularly rich flowering trees, sometimes feeding alongside the Nile Valley Sunbird and Palestine Sunbird.[294]

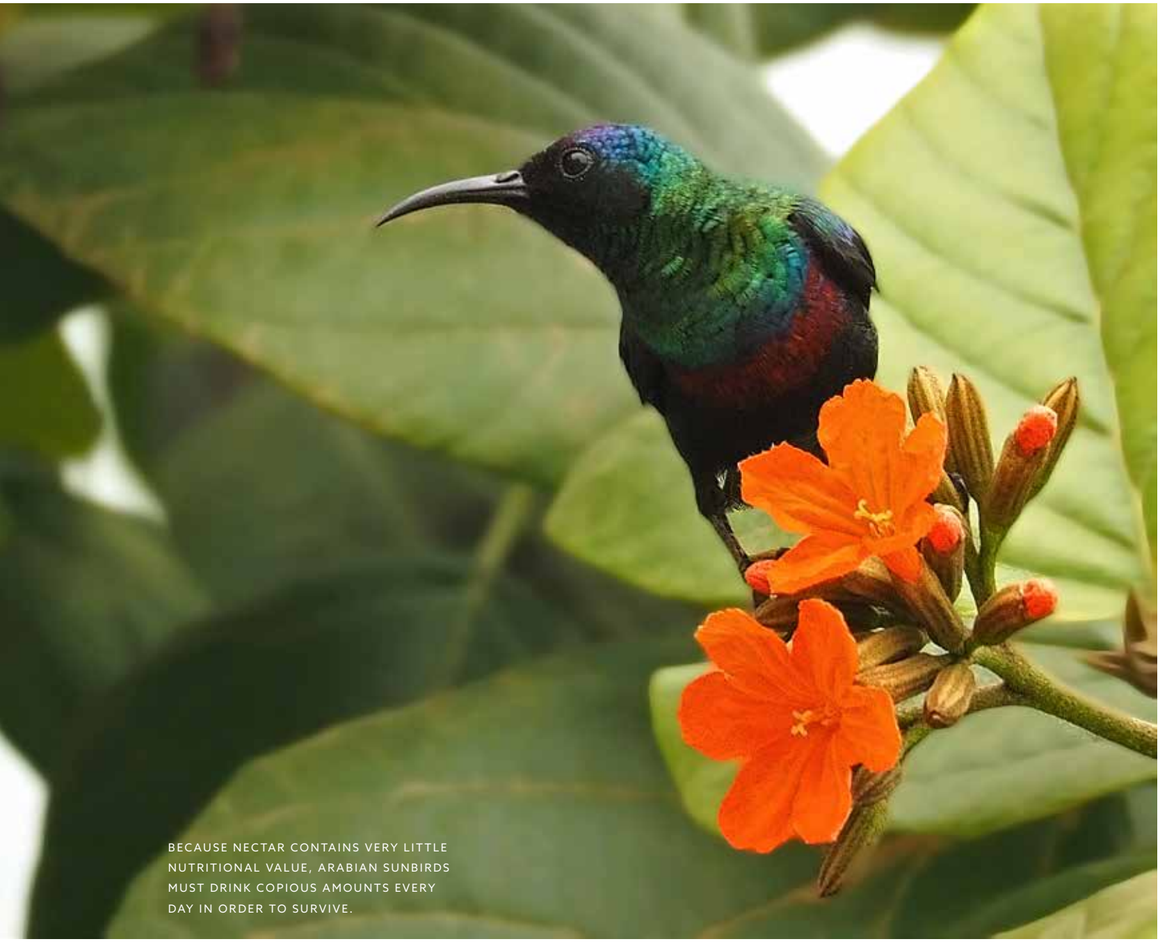
Arabian Sunbirds have been recorded foraging on a wide range of flowering plants, particularly trees (White Gul Mohur, Maerua, Moringa, Calotropis, Oleander and various acacia) but also shrubs (Anisotes) and smaller flowering plants (Aloe and Capparis).[295] However, they are likely to take nectar from a much wider range of plant species than reported to date (including figs, Date Palm, Salvia, Stereospermum, Ziziphus, Toothbrush Tree and many others, which the closely related Shining Sunbird has been recorded exploiting in Africa).[296]

Sunbirds are highly adapted to drinking nectar. To feed, the bird places its narrow pointed bill into the base of the flower and begins to suck up the sweet nectar. The edges of the tongue are rolled inwards to form two parallel tubes (like two drinking straws) that separate near the end to give the bird a forked-tipped tongue. Each tip is frayed at the edges to help sweep up as much nectar as possible, which is then sucked through the tubular tongue and into the throat. Two grooves in the palate help to pump yet more nectar into the mouth.

The problem with nectar is that it contains very little nutritional value: it is after all mostly water with a small amount of simple sugar. To compensate for the lack of protein, nitrogen and electrolytes in nectar, sunbirds supplement their diet with invertebrates (and possibly pollen), particularly during periods of high-energy demand such as breeding or molting, when some sunbird species will spend almost 20% of their time searching for arthropods.[297]

Moreover, in order to obtain enough energy to survive, sunbirds must consume copious amounts of nectar.[298] Consequently, these gorgeous little birds spend about 80% of their day zipping about from tree to tree and flower to flower, feverishly drinking the sweet sugary liquid. By the end of the day, each sunbird has consumed around 3–5 times its body

To obtain enough energy, Arabian Sunbirds consume around 3–5 times their body weight in nectar every day. This is equivalent to an adult human drinking 1500 cups of sugary water every single day.



BECAUSE NECTAR CONTAINS VERY LITTLE NUTRITIONAL VALUE, ARABIAN SUNBIRDS MUST DRINK COPIOUS AMOUNTS EVERY DAY IN ORDER TO SURVIVE.

It is quite ironic that a small bird foraging in the hot and dry climate of Saudi Arabia should be faced with the problem of consuming too much water.

weight in nectar. To help put that in perspective, this is equivalent to an adult human weighing 75 kilograms drinking 900–1500 cups of sugary water every single day. Not only that, sunbirds must rapidly warm this liquid to body temperature and pass the liquid through their digestive system as quickly as possible (to minimize mass gain, which would interfere with flight), while somehow absorbing all of the energy needed to sustain themselves.[299] The sunbird's kidneys simply cannot keep up with the enormous quantity of liquid entering the bird's body; instead, much of the liquid is shunted directly into the intestines for nutrient absorption.[300] Obviously large quantities of diluted urine are excreted, but considerable amounts are also readily lost through the breath and across the skin's surface.[301] Thus, compared to the skin of the Arabian Lark, which is highly modified to prevent water loss, the skin of the Arabian Sunbird is positively porous. It seems rather ironic that a small bird foraging in the extremely hot and hyper-arid deserts of Saudi Arabia should be faced with the problem of consuming too much liquid.

BREEDING BIOLOGY

As magnificent as the plumage of the male Arabian Sunbird appears to human eyes, it is likely to appear even more magnificent to other birds. That's because birds can see colors in the ultraviolet part of the spectrum, whereas humans cannot – and birds with iridescent blue, purple and green plumage tend to positively glow in ultraviolet. In contrast, birds with brown plumage, such as the female sunbird, usually reflect much less ultraviolet light. Further, bird vision is ten times more sensitive to ultraviolet light than to light reflected

UNLIKE THE FLASHY MALE, THE FEMALE ARABIAN SUNBIRD IS GREY-BROWN, WHICH HELPS CONCEAL THE FEMALE WHEN NESTING.

THE FEMALE ARABIAN SUNBIRD BUILDS THE NEST, INCUBATES THE EGGS, AND PROVIDES MOST OF THE FOOD TO THE CHICKS.

in the rest of the spectrum.[302] Thus while the male and female Arabian Sunbird appear completely different from one another, they are in fact vastly more different from each other than we can even imagine.

The extreme sexual dichromatism in Arabian Sunbirds is probably the result of at least two opposing forces: on the one hand choosy females have been continually selecting the highest quality males based on the incandescence of their plumage, while on the other hand natural selection has favored females that are less conspicuous as an aid for camouflage while nesting.[303]

Being bright and conspicuous is costly. Not only does it require additional testosterone (which suppresses the immune system),[304] it also makes individuals more conspicuous to predators.[305] As a result, male-biased mortality rates are usually higher in sexually dichromatic species.[306] Since male sunbirds are so much more conspicuous and vulnerable to predation than females, we might expect that the males would be more likely to skulk in bushes and trees as a way of avoiding predators. However the exact opposite occurs. For example, at any time of year female Palestine Sunbirds spend only 9% of their time perched in visible locations. In contrast, during the autumn male sunbirds spend 26% of their time in exposed locations, while in spring they make themselves even more conspicuous spending a whopping 74% of their time in highly visible positions within their territories.[307] Similar behavior is expected to occur in Arabian Sunbirds in which it is quite apparent to even the casual observer that males spend far more time in exposed locations than the much more secretive females. Indeed, the reason why this family of birds is known as sunbirds is because the males prefer to forage and perch in open sunny locations. The males intentionally place themselves in a light environment that maximizes the amount of ultraviolet light reflecting off their display feathers.[308] The male's desire to display its luminous feathers in order to attract a mate is so great that it outweighs the significant risks and potentially catastrophic effects of predation.

Arabian Sunbirds actively court females through song, plumage displays and chases. As is the case for most sexually dichromatic species,[309] only the male Arabian Sunbird sings. The song has not been described, but in other *Cinnyris* sunbirds it usually consists of a complex and melodious series of metallic trills and whistles that can last for several minutes and occasionally incorporates mimicry of other species (as recorded in Palestine

These birds are called sunbirds because the males prefer to forage and perch in exposed sunny positions, thereby maximizing the amount of ultraviolet light reflecting off their display feathers.

The male's desire to display its luminous feathers in order to attract a mate is so great that it outweighs the significant risk of predation.

While species with extreme sexual dichromatism like the Arabian Sunbird may be socially monogamous, most are far from genetically monogamous.

A MALE ARABIAN SUNBIRD FEEDS A NEWLY FLEDGED CHICK – BUT IS HE THE BIOLOGICAL FATHER?

Sunbirds).[310] The courtship display probably resembles that of the closely related Shining Sunbird in Africa in which a male will stand tall and shuffle along a perch towards a female, swing his body from side to side and suddenly fluff out its plumage and expose its pectoral tufts. Some birds then take off vertically and return to the same perch to sing.[311] In Arabian Sunbirds, the male has a jerky song flight where the tail is lowered to enhance the feathers around the rump. In some cases, the male Arabian Sunbird will actively chase the female, display, and then copulate.[312]

Given the high likelihood of infidelity and nest destruction in Arabian Sunbirds, it is not surprising that males become highly territorial during the breeding season.

Arabian Sunbirds appear to form socially monogamous pairs. However, while species with extreme sexual dichromatism may be *socially* monogamous, most are far from *genetically* monogamous. The results of large-scale analyses of sexual dimorphism in birds reveal that species with striking plumage-color dimorphism are more likely to demonstrate high levels of infidelity; this is particularly true for species in which the male plumage is dominated by iridescent blues, purples and blacks.[313]

Accordingly, while most sunbirds are *socially* monogamous, some species have been shown to exhibit high levels of extra-pair copulations, polyandry (where the female has multiple male partners) or polygyny (where the male has multiple female partners).[314] Some pairs of sunbirds are known to mate multiple times (for example, one pair of Purple-rumped Sunbirds *Leptocoma zeylonica* was seen to mate three times within a four-hour period), while others (e.g. Malachite Sunbird *Nectarinia famosa*) have been observed to peck at the female's cloaca, presumably to determine whether the female has mated with another male,[315] which are behaviors typically associated with high levels of extra-pair paternity. Indeed, studies of the Palestine Sunbird have revealed that these tiny birds lead exceptionally complex social lives where in any given year virtually half of all breeding females raise a nest that includes at least one young that is not fathered by her social partner. While such studies have not been conducted in Arabian Sunbirds, males have been seen courting two females simultaneously.[316] In short, it is highly likely that there are very high levels of extra-pair copulations in Arabian Sunbirds.

Interestingly, when a male sneaks away to search for another bird to mate with he runs the risk of other males coming in to his territory and courting his female. Further, he leaves the nest itself vulnerable to attack. In Palestine Sunbirds, for example, rival males will destroy an exposed nest (and kill the young chicks), presumably to trigger the female to become fertile again thereby increasing his chances of obtaining an extra mate.[317] It is therefore especially interesting that there have been several reports of nest demolition in Arabian Sunbirds.[318]

Given the high likelihood of infidelity and nest destruction in Arabian Sunbirds it is not surprising that males become highly territorial during the breeding season. Individual birds will aggressively evict rival males, as well as other species, including birds as large as the Laughing Dove,[319] which is about 10 times heavier than a sunbird. Territory defense and mate guarding is likely to be most intense at the start of the nest attempt, particularly in the period leading up to laying when the female is fertile.

In species that are sexually dichromatic males tend to spend little or no time in nest building and incubation of the eggs and brood young,[320] and this is certainly true for Arabian Sunbirds. The female builds the nest alone, often with the male in close attendance, singing and engaging in territorial behaviors.[321] The nest is suspended usually between 1.5–5 meters above ground level (though sometimes as high as 9 meters) from a spindly outer branch of a bush or tree (often an acacia or some other thorny species; though one nest was recorded suspended from a wire cable). The nest is an enclosed, vertically elongated, oval shape woven from grass and plant down with an entrance in the side near the top with an overhanging "porch",[322] perhaps built facing away from the prevailing wind (as documented in Palestine Sunbirds).[323] The nest is bound with fibers, such as plant down, fine grasses, cocoons and cotton wool like material, with a high proportion of cobwebs, which can make the structure appear almost white. The inside of the nest is lined with more plant down, cobwebs, wool, and sometimes feathers.[324]

The clutch usually contains only one or two eggs, which is very typical of all *Cinnyris* sunbirds. The female alone incubates the eggs, which are bright white and speckled with black streaks on the broader side.[325] Both the Diederik Cuckoo and Klaas's Cuckoo have been recorded parasitizing the nests of at least 16 species of sunbirds in Africa, including six species of *Cinnyris* sunbirds.[326] Thus it is likely that these extraordinary cuckoos will attempt to deposit their eggs in the nests of Arabian Sunbirds. Furthermore, female sunbirds occasionally dump some of their eggs into a neighbor's nest as well. For example, studies of Palestine Sunbirds have revealed that about 6% of nests contain eggs that have been deposited by a rival female.[327]

The duration of the incubation and nestling periods is unknown, but is likely to be around 12–15 days and 13–17 days, respectively (based on data from nine other well studied species of *Cinnyris* sunbirds).[328] Both adults bring food to the nestlings,[329] though it is likely that the female provides the majority of food to the chicks, while the male provides most of the nest defense (as demonstrated in other sunbirds in the region; e.g., Palestine Sunbirds and Purple Sunbirds *C. asiaticus*).[330] Because sunbirds do not have a specialized crop, the adult birds cannot store and then regurgitate nectar to their chicks. Instead they feed their young whole insects up to the size of a caterpillar. As recorded in several other sunbirds, the young may return to roost in the nest for several days after fledging, and both parents will continue to feed the young for at least another week.[331] Arabian Sunbirds have a rather long breeding season, which implies they may be double-brooded.[332] Ringing studies suggest that sunbirds can live for around eight years in the wild.[333]

Both Diederik Cuckoo and Klaas's Cuckoo are likely to deposit their eggs in the nests of Arabian Sunbirds.

CONSERVATION STATUS

The global population of Arabian Sunbirds is estimated to be around 500,000 annual breeding pairs, with about half of the population nesting in Saudi Arabia (*see* Table 1). The IUCN lists the species as least concern on account of the very large population size and extensive range and stable in the absence of any clear evidence of a decrease in population size.[334] The species occurs in several protected areas in Saudi Arabia.

DIEDERIK CUCKOOS ARE LIKELY TO SECRETLY DUMP THEIR EGGS INTO THE NESTS OF ARABIAN SUNBIRDS.

ARABIAN WAXBILL: ENDEMIC TO THE ARABIAN PENINSULA.

ARABIAN WAXBILL (*ESTRILDA RUFIBARBA*)

The Arabian Waxbill is perhaps the most enigmatic bird in Saudi Arabia. Even though Western scientists first discovered this species in 1851, it was not until 2016 that the first nest was found and described.[335] This is partly because it is one of the most difficult endemics to see: it usually lurks amidst relatively dense vegetation, occasionally darting out into open areas to feed or collect nest material. Not only is it somewhat secretive, the Arabian Waxbill is also small. In fact, weighing 8.5 grams and standing 10 centimeters tall,[336] the Arabian Waxbill is one of the lightest birds in Saudi Arabia and the smallest regional endemic.

At first glance, this dainty bird seems rather pale and unremarkable, but on closer inspection it is, in fact, most delicately ornamented. The feathers on the body and wings are ever so finely barred with alternating grey and brownish-white stripes, which merge into a buffy white chest and pure white throat. The black tail contains an elegant white trim. In the female and juveniles, a dark stripe overlays the eye. In the male, the eyestripe is a glorious scarlet, dramatically offsetting the subtle tones of the rest of the face and body. It is as if the bird has been painted by the most sensitive of artists.

These petite birds belong to the family known as the estrildid finches (or more formally the Estrildidae), which contains 134 species worldwide. The genus that includes the Arabian Waxbill (*Estrilda*) contains 14 species: 13 of those species occur in Africa, while the Arabian Waxbill is endemic to the Arabian Peninsula, occurring only in the southwest of Saudi Arabia and Yemen.

THE ARABIAN WAXBILL OCCURS ONLY IN SAUDI ARABIA (SOUTH FROM MAKKAH) AND YEMEN, MAINLY ABOVE 1,000 M.

THE ARABIAN WAXBILL IS OFTEN FOUND NEAR FRESHWATER AND AREAS CONTAINING DENSE TREES AND BUSHES.

HABITAT

In Saudi Arabia, Arabian Waxbills have been recorded from Wadi al-Saylah just north of Tayif and Makkah south to the Yemen border. Although it has been recorded from near sea level to 2,700 meters in Yemen, in Saudi Arabia it is found most often in the Tihamah lowlands and western slopes between 1,000–2,500 meters.[337] Notwithstanding, the only two records of nesting behavior in this species come from 549 meters and 2,800 meters.[338] The Arabian Waxbill prefers habitats containing a dense cover of trees and bushes, from highland juniper forests, to subtropical forests, cultivated terrace slopes, rocky scrubby hillsides, and scrub-filled wadi basins. It is often found near freshwater (including reedbeds and boggy ground) where it regularly drinks and occasionally bathes.[339] Consequently, Arabian Waxbills are often found in irrigated cultivated areas (especially cereal crops).

Arabian Waxbills appear to be sedentary with the possibility that some populations move to slightly higher altitudes in summer to avoid the heat.[340] This would be in keeping with their African counterparts: all other species in the genus *Estrilda* that have been studied in any detail appear to be sedentary with some species wandering locally following rains.[341]

FORAGING ECOLOGY

The diet and foraging ecology of Arabian Waxbills have not been studied in any detail. However, casual observations suggest they feed mainly on the seeds of native and cultivated grasses (e.g., *Sorghum*), rushes (*Juncus*), grains (*Maize*), and flowering plants (including *Jatropha*, *Chenopodium*, *Tamarix*, and *Aerva javanica*). They either take seeds directly from the seed head or strip the seeds from the plant before picking them from the ground. They will also forage along the ground in search of dropped seeds.[342] Much like the beaks of true finches, the deep, pincer-like bill of the Arabian Waxbill certainly appears to be well adapted to cracking seeds. Nonetheless, like all other members of their genus, Arabian Waxbills probably also supplement their diet with small insects (especially ants and termites) and occasionally nectar.

Like all of the African members of its genus, the Arabian Waxbill is highly social. While it can be recorded singly or in pairs, it is more often seen in small groups sometimes containing up to 30 or even 60 individuals.[343] In some cases, hundreds of individuals have been observed gathering before roosting communally.[344] It has been reported to forage and even roost in mixed flocks with other estrildid finches (such as African Silverbill), presumably as a way to dilute predation risk.[345]

While the Arabian Waxbill can be recorded singly or in pairs, it is more often seen in small groups sometimes containing 30 or even 60 individuals. In some cases, hundreds of individuals gather before roosting communally.

VARIATION IN THE RED EYE STRIPE OF THE ARABIAN WAXBILL SUGGESTS IT PLAYS AN IMPORTANT ROLE IN MATE CHOICE.

BREEDING BIOLOGY

Very little is known about the breeding biology of this sweet little bird. There are no published reports of courtship or mate choice in this species. However, two aspects of the eyestripe strongly suggest it is a sexual signal used in mate choice: (i) it is most intense in adult males, and (ii) it is bright red, which indicates it is clearly an ornament and not for camouflage. The bright red plumage in Arabian Waxbills is significant because it requires a red carotenoid pigment that birds are unable to manufacture themselves.[346] They simply lack the metabolic machinery required to create red coloration. So in order to produce their beautiful red eyestripe Arabian Waxbills must *consume* carotenoid pigments in their diet. However, the seeds consumed by Arabian Waxbills do not contain red pigments; instead, they contain only yellow pigments (called xanthophylls). Thus, seed eating birds use metabolic processes to convert the yellow pigmentation to red pigmentation, which is an energy-demanding process. Therefore only the highest quality individuals have enough energy to be able to produce additional red coloration.[347] Indeed, some male Arabian Waxbills produce so much red pigmentation that the base of their bill also reddens during the breeding season. These are presumably the highest quality males.

Furthermore, consuming lots of carotenoid pigments is good for the bird's health because carotenoids are antioxidants and stimulate the immune system.[348] Thus, in Arabian Waxbills, a larger, more defined, more saturated red eye stripe is likely to be attractive to females because it demonstrates foraging ability, general health and overall male quality. This has been demonstrated experimentally in the closely related Common Waxbill (*Estrilda astrild*): males with more saturated red coloration around the face and bill are in better body condition than those with less red plumage.[349] Accordingly, when given a choice in captivity female waxbills prefer males with more saturated red plumage.[350]

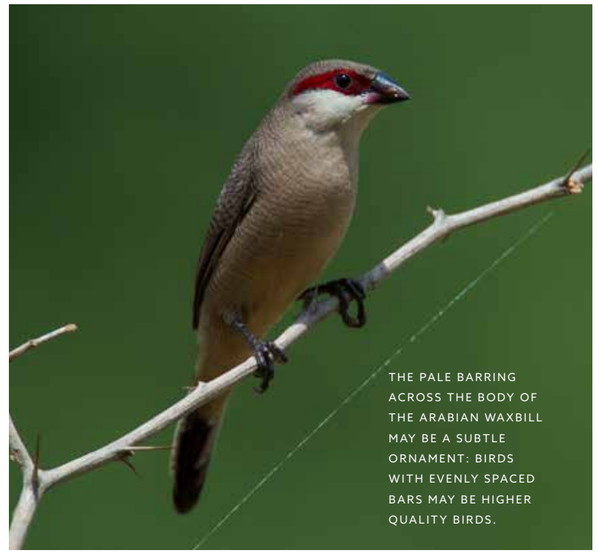
Another less obvious plumage signal in Arabian Waxbills is the alternating darker and lighter transverse bars across much of the body and wings. Such barring is common in birds as it serves as a form of "motion camouflage": that is, birds with barring are more difficult for predators to detect or follow.[351] Interestingly, the regularity or neatness of such barring serves as a sexual signal and as an indicator of individual quality. For example, in Common Waxbills adults have more perfectly delineated and more continuous barring than juveniles, and adult males likewise have more regular barring than adult females. Furthermore, males in better body condition have more regular barring patterns than males in poor health.[352] These results strongly suggest that the barring patterns on waxbills can be used to assess individual quality, for example while assessing one another during their delightful courtship rituals described below.

Very little is known about the breeding biology of this sweet little bird.

Horizontal barring across the body and wings is common in birds as it serves as a form of motion camouflage: predators find it more difficult to detect or follow a bird with such bars.

Although courtship has not been reported for Arabian Waxbills, courtship behavior has been described for ten of the 14 species of *Estrilda* waxbills. Across these ten species, courtship behavior appears to be quite similar, suggesting that the Arabian Waxbill is likely to engage in a similar ritualized courtship display. In the case of the Common Waxbill (which is the most studied of the waxbills), the male takes a slender grass stem in its bill and flies to perch next to the female. It then holds the stem with its head held high, fluffs its belly and flank feathers, tilts its body away from the female to expose its underparts, angles the tail and head towards her, jerks up and down a few times by stretching and flexing the legs, and then sings. The female responds with more or less the same display, except that she does not sing.[353]

Amazingly, although an estimated 35,000 annual breeding pairs of Arabian Waxbill exist, only one nest has ever been observed and reported in the literature, which was discovered by some of the contributors to this book.[354] A second nest for this species was inferred when individuals were observed repeatedly carrying nest material at 2,800 m, but the nest was not found.[355]



THE PALE BARRING ACROSS THE BODY OF THE ARABIAN WAXBILL MAY BE A SUBTLE ORNAMENT: BIRDS WITH EVENLY SPACED BARS MAY BE HIGHER QUALITY BIRDS.

Although an estimated 35,000 annual breeding pairs of Arabian Waxbill exist, it was not until 2018 that the first nest was observed and reported in the literature.

THE ONLY NEST OF AN ARABIAN WAXBILL EVER REPORTED. THE NEST CONTAINS A TINY ENTRANCE HOLE NEAR THE BOTTOM AND A FALSE NEST ON TOP, WHICH IS DECORATED WITH GREY AND SILVER OBJECTS.

The one studied nest was located near a wide flat wadi around 10 kilometers northeast of al-Makhwah at 549 m above sea level in an area containing cultivated wheat fields alongside banana, cacao and papaya trees. The surrounding area contained patches of acacia and Ghaf trees. The nest was built on the ground and pressed against the base of a terrace wall amongst cultivated fields.[356]

Around 4 hours of digital recordings at the nest revealed that both members of the pair worked together to build the large messy nest made almost entirely of long grass stems woven together to form a bulbous dome about 25 centimeters long, 20 centimeters high and 20 centimeters wide. A tiny entrance about 3 centimeters in diameter was built near the bottom of the dome that was invisible when looking down at the nest. The male collected the nest material and brought it to the female who then proceeded to weave the material into the nest. A false nest dome (about 10 x 10 x 10 centimeters) was constructed on top of the main nest, presumably as a means of deceiving potential predators. The false nest was lined with downy feathers, and decorated with pieces of greyish plastic, bulbous white objects and thin wispy seedpods, which made the false nest look like an old abandoned nest complete with fake fecal sacs and remnants of a nest lining, thereby further dissuading predators. Both the male and female took considerable time to place the decorations in the false nest, carefully relocating and rearranging each item for more than two minutes at a time to make the false nest seem as real as possible. When completed, the clutch consisted of five pearly white and almost spherical eggs. Both male and female contributed to the early stages of incubation, each spending about a quarter of their day actually inside the nest.[357]

Unfortunately, that is all that can be said about the nesting behavior of this lovely endemic bird. The only nest that has ever been found was inadvertently destroyed before the eggs had hatched when a farmer cleared vegetation surrounding the nest.[358] Thus there are still no observations of the nestling or fledging phases of Arabian Waxbills.

There are still no observations of the nestling or fledging phases of these delicate waxbills.

If the Arabian Waxbill exhibits similar nesting behavior to *Estrilda* waxbills in Africa (which have been relatively well studied), then we might expect Arabian Waxbills to have an incubation period of around 11–13 days followed by a nestling phase of around 18–21 days, with juveniles fed by both parents until they achieve foraging independence around 14–35 days after fledging. They may also be double brooded.[359]

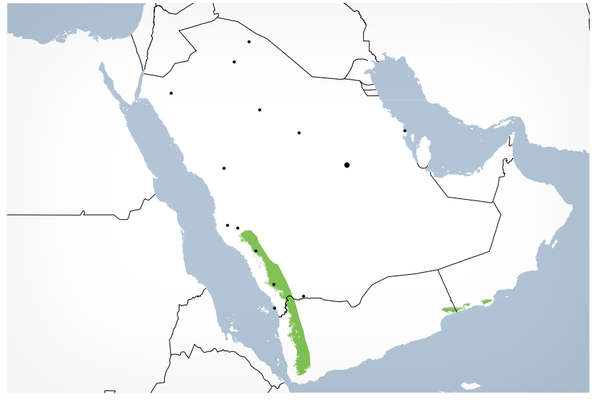
THE WORLD POPULATION OF ARABIAN WAXBILLS IS CONFINED TO SAUDI ARABIA AND YEMEN.

CONSERVATION STATUS

The entire global population of the Arabian Waxbill is restricted to two countries, Yemen and Saudi Arabia. An estimated 25,000 breeding pairs occur in Yemen, while only 5,000 breeding pairs exist in Saudi Arabia making it one of the rarest endemic birds in the Kingdom (*see* Table 1). The IUCN lists the species as least concern due to the reasonable population size, which is spread over a large range. However, the Arabian Waxbill is listed as decreasing due to habitat loss as a result of the increasing use of modern agricultural techniques in parts of its range.[360] Modern irrigation techniques (increasing farmed areas adjacent to surface water) are perhaps beneficial to the species.

ARABIAN GROSBEAK (*RHYNCHOSTRUTHUS PERCIVALI*)

The Arabian Grosbeak is probably the most difficult endemic bird to find. Confined to Saudi Arabia, Yemen and western Oman, this very rare finch is scarce throughout its range and becoming scarcer. Only 500 pairs remain in the Kingdom. If you are lucky enough to see an Arabian Grosbeak it usually flies away immediately. This bird is so rare and so inscrutable that no nest has ever been recorded in Saudi Arabia, and it has been more than 25 years since anyone reported seeing a nest anywhere.



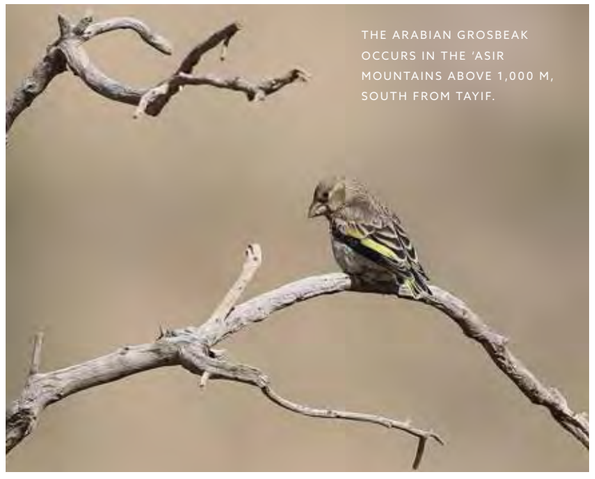
ARABIAN GROSBEAK: ENDEMIC TO THE ARABIAN PENINSULA.

Although Western scientists first discovered Arabian Grosbeaks in 1900, modern statistical analyses were necessary to indicate that the Arabian Grosbeak is indeed a separate species.

No Arabian Grosbeak nest has ever been recorded in Saudi Arabia, and it has been more than 25 years since anyone reported seeing a nest anywhere.

This species is so unknown that there is still uncertainty as to whether the Arabian Grosbeak is actually an endemic species. Western Scientists first discovered the Arabian Grosbeak near Yeshbun (Hadramut, Yemen) in 1900 only a few years after discovering similar looking grosbeaks at Socotra and Somalia.[361] Ever since then there has been debate as to whether the three isolated populations represent three different species or simply one species that occurs in three different places. However, modern statistical analyses indicate that the three grosbeak populations are indeed sufficiently distinct from each other (in terms of plumage and morphology) to be regarded as three separate species, although genetic testing is required to confirm this position.[362] Accordingly, most modern taxonomies recognize three separate species of grosbeak: the Arabian Grosbeak (*R. percivali*), the Socotra Grosbeak (*R. socotranus*) and the Somali Grosbeak (*R. louisae*).[363] None of these species are particularly common: perhaps only 10,000 breeding pairs remain for all three species combined.

Arabian Grosbeaks are one of 144 species from 29 genera that belong to the Fringillidae family, otherwise known simply as the finches. The genus containing the Arabian Grosbeak (*Rhynchostruthus*) contains only the three species mentioned above, and none of these have been studied in any detail. However, the Arabian, Socotra and Somali Grosbeaks (i.e., the *Rhynchostruthus* genus) are closely related to birds in the large *Carduelis* genus,[364] which includes some exceptionally well-studied birds, such as the Eurasian Siskin, European Goldfinch, European Greenfinch (*Chloris chloris*), and American Goldfinch (*Spinus tristis*). Therefore studies of these cardueline finches can shed some light on the behavioral ecology of the Arabian Grosbeak.



THE ARABIAN GROSBEAK OCCURS IN THE 'ASIR MOUNTAINS ABOVE 1,000 M, SOUTH FROM TAYIF.

HABITAT

In Saudi Arabia, the Arabian Grosbeak occurs from about Tayif south to Yemen. Within the Kingdom it is primarily a highland species occurring from 1,000 m up to the highest summit in Saudi Arabia. (In Oman and parts of Yemen it is often recorded near sea level). It occurs mainly in scrub-covered rocky outcrops, slopes, high plateaus and dry wadis with mixed succulents, bushes and trees (including juniper, acacia and euphorbia), and usually near freshwater from which it occasionally drinks. It is sometimes recorded at the edges of cultivated croplands, though it generally does not feed on the crops themselves. It avoids purely arid regions and human sites.[365] Arabian Grosbeaks are year round residents with some post-breeding dispersal and partially nomadic flocks.

FORAGING ECOLOGY

Like most finches, the Arabian Grosbeak feeds on a wide range of seeds and fruit, including euphorbias, myrrh, juniper berries, Ziziphus fruits, and the seeds or buds of acacia. The Arabian Grosbeak's sizeable conical bill allows it to manipulate and crush hard seeds and large fruits that finches with smaller bills simply could not exploit. It feeds in bushes and the crowns of trees and will sometimes twist, stretch and hang upside down acrobatically to reach fruits and seeds. It rarely forages on the ground, though it does come down to drink. Arabian Grosbeaks are generally shy and elusive and often inactive, especially in the early afternoon, where they skulk in leafy bushes. They become most active before dusk.[366]

During the non-breeding season, Arabian Grosbeaks generally forage in small groups of up to 30 individuals. Flocks of Socotra Grosbeaks make daily journeys from their high altitude roosts to feeding sites at lower altitudes, and as Arabian Grosbeaks have been reported roosting in flocks on hilltops, they could conceivably undertake similar daily movements.[367]

Most cardueline finches (along with many other passerines) possess a black face patch or bib that advertises the social status of the bird. For example, Eurasian Siskins with larger black bibs are socially dominant birds: they are more aggressive and initiate more fights than individuals with smaller black bibs, and even force their subordinates to regurgitate food to them.[368] Consequently, individuals with smaller black bibs tend to avoid

THE LARGE, CONICAL BILL OF THE ARABIAN GROSBEAK IS SPECIALIZED FOR FEEDING ON FRUITS, BERRIES AND SEEDS.

Arabian grosbeaks possess a black face patch that advertises the social status of the bird. Birds with more black in the face and chest are socially dominant.

foraging near dominant birds with larger bibs, presumably to avoid such costly encounters.[369] By conducting experiments in which the size of the black bib was artificially enlarged or reduced with paint, researchers have demonstrated that individuals truly assess a fellow group member's dominance status on the basis of the bib size alone (eliminating other potentially confounding factors such as body size or behavior).[370] By assessing the size of a group member's black bib or face pattern, individuals competing for food resources do not need to risk injury or waste energy fighting with their competitors. While the black face patch in Arabian Grosbeaks is rather small, it is nonetheless variable between individuals and possibly serves a similar signaling function.

The most striking plumage ornament of the Arabia Grosbeak is the magnificent golden bar in the wings (indeed, one of the common names for this bird is the Golden-winged Grosbeak). Interestingly, while the black facemask may reveal an individual's social status, these beautiful wing bars could reveal its foraging ability: in other species, individuals that are more effective foragers develop more intensely golden plumage.[371] This is because carotenoid pigments are required to produce the color yellow in birds, and since birds are unable to manufacture carotenoids themselves, they must ingest these pigments by eating large amounts of plants, algae, bacteria or fungi (which can manufacture carotenoids). The ingested carotenoids are then transported through the bloodstream and deposited into the feathers or bare parts to produce the vivid yellow coloration. Many experiments on several cardueline finches with yellow plumage demonstrate that individuals that are unable to find enough food display less intense yellow coloration in their feathers, whereas individuals that find abundant food produce more dramatic golden plumage.[372]

The most striking plumage ornament of the Arabia Grosbeak is the magnificent golden bar in the wings. Interestingly, the brightness and size of these wing bars is an indicator of foraging success.

Not only do well-fed cardueline finches have brighter, more intense golden plumage, they are

Arabian Grosbeaks with brighter golden plumage are better able to fight off infectious diseases.

also better able to fight off infectious diseases.[373] Experiments in European Greenfinches, for example, show that individuals with brighter plumage are able to mount stronger immune responses against novel antigens and are in generally better health.[374] This is because carotenoids are not just pigments; they are also powerful antioxidants that play a key role in many vital processes including supporting the immune system. Thus, the level of circulating carotenoids in cardueline finches plummets (by about 25% in the European Greenfinch) when the bird becomes infected with a disease because some of the carotenoids have been redirected to fight the infection.[375] Thus, an Arabian Grosbeak with particularly bright golden wings bars is displaying to all members in its foraging group that it is in great health and has been able to find plenty of seeds and fruit, which are obviously attractive features to potential mates.

BREEDING BIOLOGY

No egg or chicks have ever been reported and no incubation or brooding behavior has ever been described for this rare bird. Not one nest has ever been found within Saudi Arabia.

Unfortunately, almost nothing is known of the breeding biology of this rare endemic species. Indeed, only two nests have ever been described, both from the same site in Oman in 1992. No egg or chicks have ever been reported, and no incubation or brooding behavior has ever been described. While there have been a few records of fledglings in the southwest of the Kingdom, not one nest has ever been reported from within Saudi Arabia. Equally little information exists about the breeding biology of its closest relatives, the Socotra Grosbeak and the Somali Grosbeak. Thus, much of the account below is based on general patterns of behavior observed in well-studied and closely related cardueline finches.

The golden wings of the Arabian Grosbeak no doubt play an important role in mate choice at the start of each breeding season. As discussed above, the golden plumage of finches is a good indicator of the foraging efficiency and current health status of individual birds. Therefore it is not surprising that numerous experiments have demonstrated that cardueline finches prefer to mate with individuals with brighter and/or larger yellow plumage ornaments.[376] Both males and females prefer to partner with birds displaying brighter yellow coloration. As a result, high quality females with bright yellow plumage select high quality males with bright yellow plumage, whereas low quality males pair with low quality females in a process known as assortative mating.[377] Since both male and female Arabian Grosbeaks possess bright golden wing bars, it is likely that they too pair assortatively according to the size or intensity of this trait.

THE ARABIAN GROSBEAK IS ALSO KNOWN AS THE GOLDEN-WINGED GROSBEAK. THEIR GOLDEN WING BARS ARE LIKELY TO BE USED IN ASSESSING INDIVIDUAL QUALITY DURING THE BREEDING SEASON.

To court the female, Male Arabian Grosbeaks perform a mixture of stiff-winged slow-motion gliding flights, fluttering bat-like flights, and spiraling parachuting flights. The male also attracts a female through song.

Song is also likely to be an important component of mate choice in Arabian Grosbeaks. These are vociferous birds that call and sing frequently, especially in mid morning, late afternoon, and most of all in the hour before dusk. Individuals usually sing for several minutes at a time; indeed one bird was recorded singing continuously for 13 minutes,[378] which is an energetically costly activity. Given that Arabian Grosbeaks are not territorial during the winter, song is probably used as a way of broadcasting individual quality to potential mates in the weeks leading up to and during the breeding season.

Pairs begin to form as the breeding season approaches. In most cardueline finches, the males in the winter flock increase their singing and begin to exhibit mild aggression towards one another, often chasing and ousting other males. Moreover, they begin to approach females, often reaching out to touch or nibble a female's bill. A female signals her interest by nibbling back. As the pair bond develops, the male often performs a series of ritualized aggressive displays toward the female, even suddenly pursuing her in a brisk and spirited chase. Eventually the female begins to establish dominance over the male and, as the breeding season nears, the male begins to regurgitate seeds to the female.[379] Such allofeeding has been recorded in Arabian Grosbeaks.[380] The pair then selects a nest site and begins to defend the immediate area around the nest.

In Arabian Grosbeaks, nest building (observed at only one nest) appears to be performed by both adults,[381] which is unusual since the female alone builds the nest (with the male in close attendance) in most other fringillid finches.[382] The two observed nests (in Oman) were sited in the fork of a tree at 4 m and 8 m above the ground on a hillside containing mixed vegetation and located "quite close" to a permanent water supply. The nests consisted of an untidy, loosely built platform (roughly 90–120 millimeters in diameter and around 70 millimeters deep) built of fine grey twigs, with a shallow inner cup or depression (about 50 millimeters wide and 40 millimeters deep) made of grasses and plant fibers, with catkins and cocoons woven into the structure.[383]

The estimated global population of Arabian Grosbeak numbers only 3,000 breeding pairs, with just 500 pairs remaining in Saudi Arabia.

In some cardueline species the male often performs a display flight in front of the female as a prelude to copulation. Accordingly, male Arabian Grosbeaks perform a mixture of stiff-winged slow-motion gliding flights, fluttering bat-like flights, and spiraling parachuting flights where the wings are held above the horizontal.[384] The male also tries to attract a female through song. Typically the male Arabian Grosbeak sings from a horizontal branch, holds the wings out from the body in a drooping fashion, flutters the wings and shivers the tail,[385] thereby making the display a visual as well as an acoustic one.

In most finches, the male accompanies the female wherever she goes (a behavior known as mate-guarding) in an attempt to ensure that the female copulates only with him. The male tends to chase off other males, but not females, whereas the female will drive off intruders of either sex.[386] Nonetheless, such mate guarding is not always effective, and high levels of polygamy (5–25% of nests) have been recorded in some well-studied finches (e.g., American Goldfinch, European Greenfinch, and Common Redpoll *Carduelis flammea*).[387] Thus some level of polygamy is likely to occur in Arabian Grosbeaks.

Clutch size and egg color is variable in finches, so it is not possible to predict the clutch characteristics of the Arabian Grosbeak. In all studied finches, the female alone incubates the eggs; hence it is very likely that this is also the case for Arabian Grosbeaks. In most cardueline finches, the male feeds the female at the nest enabling her to spend up to 98% of her time sitting on the eggs. In temperate and warm climates there is little risk of unattended eggs becoming chilled. Thus, the female usually begins to incubate only once the clutch is completed so that all eggs hatch about the same time, thereby eliminating any age and size hierarchy within the brood. For the great majority of cardueline finches, incubation occupies approximately 12–14 days. The young of tree-nesting finches (such as the Arabian Grosbeak) tend to remain in the nest for around 13–16 days. In cardueline finches, the female broods the small chicks while the male brings food to the nest. Typically the male regurgitates food to the female, who in turn regurgitates it to the young, placing it inside their open mouths. Once the young are feathered the two parents forage together and take turns feeding the young. Because this food consists largely of seeds and must therefore be gathered from considerable distances, the young are fed only around 1–3 times per hour.[388]

In Arabian Grosbeaks, both parents have been recorded feeding fledged young,[389] which is typical for fringillid finches in which both parents continue to feed the young for 2–3 weeks after they have fledged.[390] The closely related Socotra Grosbeak (and thus possibly the Arabian Grosbeak) may take considerably longer to achieve foraging independence, as juveniles are still fed by adults even when post-breeding flocks form.[391] One explanation for the unusually protracted period of post-fledging parental care is that it may take a long time for young birds to develop the ability to open the particularly large fruits and seeds that Arabian and Socotra Grosbeaks consume.[392]

Nesting success of cardueline finches is often low, with crows and ravens being particularly regular nest predators of finches around the world[393] and thus it's likely that Brown-necked Ravens, Fan-tailed Ravens and possibly Asir Magpies prey on Arabian Grosbeak nests. Almost no finches suffer from brood parasitism by cuckoos. The low nesting success of finches is partly offset by producing two or three broods per season (which is made possible by the long period over which suitable seeds and fruits are available). If a second nest is initiated, the male usually continues to feed the young of the first nest while the female incubates at the second.[394]

The young of cardueline finches can become sexually mature within a few months, even before acquiring their adult plumage, and casual observations suggest this is also the case for grosbeaks. In Socotra Grosbeaks, individuals in full juvenile plumage have been recorded singing and an adult male has been seen to copulate with a female not yet in complete adult plumage.[395] After the breeding season is completed, pairs gradually reform their wintering flocks and molt into their winter plumage.

CONSERVATION STATUS

The estimated global population of Arabian Grosbeak numbers only 3,000 breeding pairs, with just 500 pairs (or 20% of the global population) remaining in Saudi Arabia (*see* Table 1). Around 2,000 breeding pairs occur in Yemen and (optimistically) 500 pairs in Oman. Surprisingly, despite the small population size, Arabian Grosbeaks are currently listed as merely near threatened by the IUCN.[396] This relatively favorable listing may be due in part to a lack of data recorded for this inscrutable bird. Furthermore, the species is becoming increasingly scarce and its range is contracting, particularly in Yemen[397] and thus it is formally listed as decreasing. Its habitat may be degraded through grazing pressure and clearance for agriculture.[398]

THE ARABIAN GROSBEAK IS PROBABLY THE MOST DIFFICULT ENDEMIC BIRD TO FIND – ONLY 500 PAIRS REMAIN IN SAUDI ARABIA.

THE ARABIAN SERIN IS USUALLY RECORDED IN THE HIGHLANDS ABOVE 1500 M SOUTH FROM AROUND MADAIN SALIH.

ARABIAN SERIN: ENDEMIC TO THE ARABIAN PENINSULA.

Fortunately, Arabian Grosbeaks can still be found in at least two protected areas in Saudi Arabia: Rayda Reserve and 'Asir National Park.

ARABIAN SERIN (*CRITHAGRA ROTHSCHILDI*)

The Arabian Serin is not likely to grace the cover of many field guides. It is not likely to be listed as anyone's favorite bird. Nor is it likely to be found in ancient Arabic poems symbolizing exquisite beauty. In short, the Arabian Serin is, well, down-right dull looking. The only apparent ornament on this drab greyish-brownish bird is the hint of a greenish-yellowish smudge on the rump; thus some people call it the Olive-rumped Serin. However, what the Arabian Serin lacks in flashy colorful plumage it more than makes up for with its truly fascinating song. This should not be sur-prising; after all, the Arabian Serin belongs to the same family as the world's most famous songbird, the canary (*Serinus canaria*).

The Arabian Serin occurs only in western Saudi Arabia and Yemen. Western Scientists first discovered the Arabian Serin in 1902 in upper Haushabi, Yemen,[399] but for decades it was treated as a subspecies of Black-Throated Canary *Crithagra atrogularis*, which is widespread across southern Africa. However, the Arabian Serin is clearly distinct and is now regarded as a separate species. It is one of 144 species from 29 genera that belong to the Fringillidae family, otherwise known simply as the finches. The *Crithagra* genus contains 37 species, including two species that are endemic to Arabia – the Arabian Serin and the Yemen Serin. While very little is known about either species, several of the other *Crithagra* finches have been very well studied and these studies can inform us about the likely behavior of the endemic serins.

What the Arabian Serin lacks in flashy colorful plumage it more than makes up for with its fascinating song. Indeed, the Arabian Serin belongs to the same family as the world's most famous songbird, the canary.

Despite its wide distribution and abundance, the breeding biology of the Arabian Serin is very poorly known. Remarkably, it was not until 2001 that the first eggs and nests were reported for this species.

HABITAT

In Saudi Arabia, the Arabian Serin can be found from around 26.5°N (near Bada and Madain Salih) south to Yemen. It is normally found between 1,500 meters and 2,500 meters, though it has been recorded from as high as 3,000 meters and as low as 700 meters (and almost to sea level in Yemen). It inhabits open areas with a good number of trees, bushes and shrubs, preferring acacia but also occurring in juniper. It is also found around cultivated areas, particularly well-wooded terraced hillsides. It has been recorded in some city gardens in Yemen, but apparently not in Saudi Arabia. It is a resident species that can be locally common in the core of its range, for example within the Rayda Reserve.[400]

FORAGING ECOLOGY

The diets of all well studied *Crithagra* finches consist primarily of seeds supplemented by growing shoots, flower buds, and occasionally small invertebrates.[401] The limited available records suggest that Arabian Serins have a similar diet. They have been recorded eating a variety of seeds (e.g., grasses, millet, aloe, agave, *Commicarpus plumbagineus*), buds (acacia, Arabian Boxthorn), and fruits (*Ochradenus baccatus*, Ziziphus), as well as some insects and larvae.[402]

Arabian Serins usually forage on the ground or in low vegetation, sometimes hanging upside down acrobatically to feed, or taking plant material to a perch to dismantle and consume.[403] Unlike most other *Crithagra* finches, which generally form winter flocks containing dozens or even hundreds of birds, Arabian Serins are not especially gregarious. Instead, they usually forage in pairs or at best in small groups, which are possibly family parties,[404] though they do occasionally form mixed-species flocks with Yemen Linnets.[405]

BREEDING BIOLOGY

Despite its wide distribution and abundance, the breeding biology of the Arabian Serin is very poorly known. Remarkably, it was not until the year 2001 that the first eggs and nests were reported for this species.[406]

At the onset of the breeding season, Arabian Serins form simple pairs that appear to defend a small nesting territory. Although there have been no studies or published records of courtship behavior or mate choice in Arabian Serins, song is likely to play an important role. Like all *Crithagra* finches, the Arabian Serin sings a complex song that to human ears sounds like a high-pitched rambling of indistinguishable tweets, trills and warbles. When slowed down and analyzed using

THE STRONG PINCER-LIKE BILL OF THE ARABIAN SERIN SUGGESTS IT FORAGES MAINLY ON HARD SEEDS.

Female serins are more attracted to males that have a large repertoire of songs, especially those that include more complex syllables that are sung at an especially rapid rate.

computer-generated sonographs, repeated "syllables" and patterns usually become apparent. Studies of the European Serin, for example, have revealed a repertoire of about 50 complex syllables, each containing up to three elements. These syllables are sung at a very fast rate (about 16 per second) and in a very predictable sequence, thereby forming discrete songs. In serins, song organization is circular: that is the bird can pick up the song at one of a few specific starting points and then stop at any point in the song.[407]

While it may seem effortless, a beautiful song requires considerable energy to produce. Metabolic rate more than doubles when serins sing, and singing in cool air – such as dawn or dusk – is particularly costly;[408] thus the metabolic rate of Arabian Serins must rise considerably when they sing in the cool morning air of early spring in the alpine regions of the Hijaz and 'Asir Mountains. Further, singing takes time away from other critical activities (like foraging) and could attract predators. What's more learning to sing complex songs involves specialized areas of the brain that are costly to develop and maintain. Because of the many costs associated with song, only the best quality individuals are able to sing frequently or are able to sing the most complex songs. In other words, song is an honest indicator of the quality and health of the individual[409] – attributes that are of great interest to a potential mate.

Accordingly, female serins are more attracted to males that have a large repertoire of songs, especially those that include more complex syllables that are sung at an especially rapid rate.[410] Numerous experiments have demonstrated that certain elements in the song are particularly attractive to female serins. These elements – which are known in the scientific literature as "sexy syllables" – have an undeniably seductive effect: females are more likely to invite copulation with males that sing songs that contain a larger number of sexy syllables.[411]

Amazingly, singing in male serins has a direct effect on the hormonal state of the female. Experiments on serins in the laboratory and in the wild demonstrate that male song can stimulate females to become fertile, start nest building and commence egg laying.[412] Even if the female does not see the male (she merely hears a playback of his song), her hormones nonetheless respond to the sound of the sexy syllables. Experiments have shown that females in captivity that merely *hear* daily broadcasts of high quality male song lay more and larger eggs that contain higher concentrations of testosterone.[413] Importantly, chicks from eggs with high testosterone concentrations beg more often, grow muscle more rapidly, and obtain greater dominance and social rank in later life.[414] In other words, when a female is paired with a high quality mate that sings attractive phrases she allocates more resources to her eggs during the pre-laying period.[415]

Given the dramatic impact of singing on female receptivity and reproductive behavior, it is not surprising that male serins sing more frequently and include more sexy syllables during the breeding season. These sexy syllables are obviously costly to perform because males drop them from their repertoire at the end of the breeding season, while continuing to sing other, less costly songs.[416] Accordingly, in Arabian Serins, song has been reported from every month except December, and is most common from March to July when the breeding season is at its peak.[417]

Once the pairs have been established, nest building and territory defense begins. Although most other serins (including the Yemen Serin) nest in loose colonies, it appears that Arabian Serins nest solitarily. While there are no reports of nest building in the literature, in every species of *Crithagra* finch studied to date the female builds the nest entirely by herself; in some species, the male occasionally accompanies her and in some rare instances he collects nesting material sporadically without actually adding it to the nest.[418] In Arabian Serins the nest is placed 2–4 m above ground on a branch in a tree (usually an acacia or juniper) or in the spindly outer branches of a bush. The nest is a compact cup of thorny twigs, grass, bark, rootlets, and spider web, lined with plant down, grass, animal hair and occasionally string.[419]

Based on a very small sample size, most Arabian Serin clutches consist of three eggs, which are pale blue with reddish-brown or purplish-black speckles. Observations at only three nests suggest that incubation is performed

THE ARABIAN SERIN SINGS A COMPLEX SONG CONTAINING TRILLS, WARBLES AND WHISTLES, WHICH PLAYS A VERY IMPORTANT ROLE IN MATE CHOICE.

AN ARABIAN SERIN NEST BUILT HIGH IN A JUNIPER TREE. VERY FEW NESTS OF THE ARABIAN SERIN HAVE EVER BEEN RECORDED OR PHOTOGRAPHED.

YEMEN SERIN: ENDEMIC TO THE ARABIAN PENINSULA.

entirely by the female with the male often perched nearby. The eggs hatch synchronously indicating that the female begins to incubate the eggs only after the clutch has been completed.[420] Given the average nesting periods of other serins, the incubation period in Arabian Serins is likely to last 13–14 days, and the chicks will fledge around 15–18 days later. It is likely that both the male and female feed the nestlings (as occurs in all other studied *Crithagra* finches).[421] Certainly both parents have been observed feeding the young once they have left the nest,[422] which (based on observations of other serins) are likely to remain dependent on the parents for another 3–4 weeks after fledging.

Little brown birds are often some of the most fascinating birds on the planet. What's more, highly social birds like the Yemen Serin always exhibit a suite of intriguing behaviors involving both cooperation and conflict.

Diederik Cuckoos have been recorded parasitizing the nests of some *Crithagra* finches in Africa (such as the Yellow Canary *C. flaviventris*),[423] and thus it is possible that some Arabian Serin nests might likewise fall victim to these remarkably beautiful and beguiling birds. The Arabian Serin's prolonged breeding season and small clutch size suggests it is likely to attempt two broods per season.[424] Individuals may live for up to 9 years.[425]

CONSERVATION STATUS

Around 260,000 breeding pairs of Arabian Serin nest in Saudi Arabia annually, equating to around 65% of the estimated global population of 400,000 pairs, with the remaining 140,000 pairs nesting in Yemen (*see* Table 1). Accordingly the IUCN has listed the species as least concern. The Arabian Serin has a large range and there is no solid evidence that the species is facing any substantial threat. However it nests in juniper trees (which are in decline) and it is often caught in traps. Therefore the IUCN lists the species as stable or decreasing.[426] Arabian Serin can be found in at least two protected areas in Saudi Arabia: Rayda Reserve and 'Asir National Park.

YEMEN SERIN (*CRITHAGRA MENACHENSIS*)

If the Arabian Serin is somewhat dull looking, then the Yemen Serin is utterly nondescript. There is not even an olive smear on the rump. Indeed the Yemen Serin is so drab that it makes the Arabian Serin appear as colorful as a peacock. But the lack of color in the plumage does not mean the Yemen Serin is uninteresting. In fact, little brown birds are often some of the most fascinating birds on the planet. Furthermore, Yemen Serins are highly social birds and, by definition, such intensely social birds always exhibit a suite of intriguing behaviors involving both cooperation and conflict.[427] Unfortunately this particular diminutive brown bird has never been the focus of any detailed study and even casual observations are rare. Indeed, despite the fact that 25,000 pairs breed in the Kingdom every year, no nest has ever been recorded within Saudi Arabia. There is no doubt that this plain little bird would prove to be endlessly interesting if it were the subject of in-depth research.

The Yemen Serin occurs only in the highlands of southwest Arabia from about Tayif southwards to Ta'izz in Yemen, with a small isolated population discovered in sinkholes in the Dhofar region of Oman in 1997.

HABITAT

In Saudi Arabia, the Yemen Serin occurs from Tayif south to Yemen, primarily in areas above 2,000 m. Though the two serins are occasionally found together, the Yemen Serin favors slightly different habitat to the Arabian Serin, preferring dry scrubby areas on open rocky hillsides, stony plateaus and cliffs. It is also found in patches of juniper forests, cultivated fields, flat degraded grasslands, and treeless areas. It drinks regularly and therefore needs to have regular access to water. It avoids truly arid sites, and – in Saudi Arabia – it avoids villages and towns (though, oddly, it is often found in towns in Yemen, including the outskirts and center of the capital, Sana'a, and has been recorded nesting in the roof of the mosque at Jabal An-Nabi Shuab, the highest point in Arabia). This sedentary species is scarce across most of its range though it can be locally common, such as around the summit of Jabal Sawda'.[428]

FORAGING ECOLOGY

The limited published information suggests that Yemen Serins probably have a typical *Crithagra* finch diet of seeds, shoots, buds, and a few invertebrates. They appear to prefer small seeds,

THE YEMEN SERIN OCCURS ABOVE 2,000 M IN THE 'ASIR MOUNTAINS SOUTH FROM TAYIF.

including those of grasses, millet and various other plants. They usually search for seeds on the ground (often amongst rocks), but will also pick seeds directly from low-lying vegetation. They come to the ground often to drink.[429]

Like most serins, the Yemen Serin forages in social groups ranging from small flocks up to around 30 or even 50 birds. One advantage of such social foraging is reduced predation pressure. Not only do birds in larger groups benefit by collectively having "more eyes" with which to detect potential predators, they also benefit simply by the old adage that "there is safety in numbers": that is, each bird in a larger group enjoys a reduced probability that *they* will be the one that is attacked if a predator strikes the group.[430] Consequently, experiments on winter foraging flocks of finches (and numerous other birds) have demonstrated that individuals in larger groups can afford to spend less time being vigilant for predators and thus can spend more time foraging.[431]

A second advantage of social foraging is that birds can observe and exploit the foraging success of group members: if an individual sees another bird foraging at a patch of food, it can easily join that bird and exploit that patch of food too. Thus, in winter flocking species like Yemen Serin the intake rate of group foragers usually increases as group size increases. However, the bird that first found the food patch may be unwilling to share the patch with the newer bird. Accordingly, dominant individuals usually act aggressively toward a subordinate bird that joins its food patch.[432]

The Yemen Serin often forages in small groups of up to 30 or even 50 birds. Birds in larger groups benefit by collectively having "more eyes" with which to detect potential predators.

YEMEN SERIN ARE TYPICALLY FOUND IN SMALL FORAGING GROUPS USUALLY CONTAINING LESS THAN 30 BIRDS.

In many bird species (including serins) males are usually socially dominant over females, which can lead to males monopolizing food patches when conditions are tough, for instance over winter or during prolonged drought. If the food shortage persists these subordinate birds can suffer increased rates of mortality. Thus in European Serins the sex ratio of foraging flocks become increasingly male-biased during winter as more and more females perish.[433] Given the extreme climate of the 'Asir Mountains, it is likely that Yemen Serins experience food shortages leading to similar increases in the mortality rate of subordinate female birds. If this is the case, then presumably the sex ratio of nestlings must be biased towards daughters to compensate for the shortage of adult females in the population.

Several *Crithagra* finches regularly forage in mixed flocks containing more than one species, and the Yemen Serin is no exception. It is often recorded foraging in mixed flocks with Yemen Linnets, which feed on a similar assemblage of seeds and buds.[434] Generally birds form mixed flocks to enhance the benefits of social foraging: reduced predation pressure and increased foraging success. Interestingly, species that forage in mixed flocks generally fall into one of two categories: those that tend to join other species (i.e., "followers"), and those that are joined (i.e., "leaders"). "Followers" in mixed-species flocks spend less time being vigilant (and more time foraging) compared to when they are in single-species flocks; however, "leaders" do not receive any of these benefits. In other words, species that are vulnerable to predation follow other species to benefit from their vigilance.[435] In the case of mixed-species flocks containing Yemen Serin and Yemen Linnet, it would make sense for a group of drab Yemen Serin to join a group of relatively gaudy Yemen Linnet – an aerial predator such as a falcon would be far more likely to detect and therefore chase the flashy Yemen Linnet. Sometimes there are benefits in "flying below the radar".

BREEDING BIOLOGY

Once again, very little is known about the breeding biology of the Yemen Serin. Despite around 25,000 pairs breeding in Saudi Arabia annually, not one nest has ever been reported from within the Kingdom. Thus, it is necessary to examine the breeding biology of closely related serins to find commonalities that probably also apply to the Yemen Serin.

Given the apparent lack of plumage ornamentation, mate choice is presumably based on other attributes, particularly song. After all, canaries and other serins are famous for their sweet song and frequent vocalizations. In other serins, courtship often involves the male singing grandly from a prominent high perch and embarking on a courtship flight, rising high and then diving fairly rapidly, before slowing to make an undulating swoop followed by a slow, butterfly-like flight, before perching next to the female; both birds begin displaying side by side, quivering their wings, pointing their bills at each other and upward toward the sky, and silently and alternately hovering over each other.[436] An abbreviated version of this behavior has been reported once in Yemen Serin in which the male augmented the display by holding a grass stem.[437]

Once paired, the business of nest building begins. Like many other serins, the Yemen Serin nests either solitarily or in loose colonies. In Oman, small colonies consist of up to 15 nests with each nest about 5–15 m from their neighbor.[438] However, as these observations are from low altitude sinkholes in Oman they may not apply to nests in the highlands of Saudi Arabia. While there are no published records of nest building in Yemen Serins, it is likely that the female builds the nest entirely by herself, perhaps with the male accompanying her on occasions (as reported in other serins).[439] The few Yemen Serin nests that have been found (in Oman and Yemen) were placed in rock crevices (or in holes in walls or buildings) usually around 2–3 m above ground, although some nests have been recorded up to 25 m above ground on a cliff face. They have also been found occasionally to use the old nests of Pale Rock Martins. The untidy nest typically has long grass stems trailing from the nesting crevice. The outer part of the nest contains small sticks and roots, sometimes augmented with colored string or other human products. The nest cup is densely lined with fine grasses, plant down, animal hair, feathers, and sometimes spider silk.[440]

The Yemen Serin is so little studied that only one clutch has ever been described: a nest in Yemen, which contained three pure white eggs.[441] No nest data has ever been reported from Saudi Arabia. Based on the behavior of other serins, the female Yemen Serin is likely to incubate alone while the male may come to the nest to feed her by regurgitating seeds. The incubation period is likely to last 13–14 days, while the nestling period will probably last 15–18 days.[442] Both adults have been observed attending the nest and regurgitating seeds to the nestlings.[443] After fledging, the young birds will remain dependent on the parents

The Yemen Serin is so little studied that only one clutch has ever been described: a nest in Yemen, which contained three pure white eggs. No nest data has ever been reported from Saudi Arabia.

LITTLE BROWN BIRDS OFTEN LEAD THE MOST INTERESTING LIVES. HERE TWO YEMEN SERIN APPEAR TO BE FIGHTING FOR SOCIAL DOMINANCE.

for another 3–4 weeks and could live for up to 9 years in the wild. The Yemen Serin has a prolonged nesting season (extending from at least March to October) and thus, like most *Crithagra* finches, is likely to be double or triple brooded. The Diederik Cuckoo parasitizes the nests of some African *Crithagra* finches, and is therefore likely to occasionally deposit eggs in the unguarded nests of Yemen Serin.

CONSERVATION STATUS

The estimated global population of Yemen Serin is around 100,000 annual breeding pairs with around 25,000 pairs (25%) nesting annually in Saudi Arabia (*see* Table 1). This fairly sizeable population is listed by the IUCN as least concern. In the absence of evidence for any declines or substantial threats the species is suspected to be stable or possibly increasing.[444] Yemen Serin can be found in at least two protected areas in Saudi Arabia: Rayda Reserve and 'Asir National Park.

YEMEN LINNET (*LINARIA YEMENENSIS*)

The Yemen Linnet is especially pretty in flight when the white wing bars are most visible. What's more, it is a vocal bird that sings a rich and musical song.

With a warm chestnut-brown color across much of the body, a rich grey head and breast, and contrasting black and white in the wings and tail, the Yemen Linnet is one of the more colorful endemic species in Saudi Arabia. They are especially pretty in flight when the white wing bars are most visible, though they are also handsome when perched and the gently forked tail becomes prominent. What's more, it is a vocal bird that sings a rich and musical song. Happily, this attractive bird is also one of the most common endemic species in the Kingdom.

The Yemen Linnet belongs to the Fringillidae family, known simply as the finches. The genus that includes the Yemen Linnet (*Linaria*) is an

YEMEN LINNET: ENDEMIC TO THE ARABIAN PENINSULA

eclectic bunch that contains only three other species (two migratory species from Europe and West Asia and a little known endangered species from northern Somalia). The Yemen Linnet is restricted to the highlands of southwest Saudi Arabia and western Yemen.

HABITAT

In Saudi Arabia, the Yemen Linnet occurs from around Tayif south to Yemen. It occurs generally above 1,800 meters and all recorded nests are from above this altitude, though it can sometimes wander as low as 900 meters outside the breeding season (and has been recorded at around 600 meters in Yemen). It tends to occur at slightly higher altitudes on the drier eastern side of the escarpment. It is found in plateaus, boulder-covered hillsides, rocky scree slopes and wadis, preferring areas with relatively generous rainfall and a good cover of trees (especially mature junipers, but also acacia) and bushes, and almost invariably within proximity to fresh water. It is often found in cultivated or abandoned terraced fields, orchards and plantations and in the vicinity of human habitation. It can be locally common to the point that it is the most abundant species in some places: for example, an estimated 500 pairs breed annually in the 1200-ha Rayda Reserve.[445]

FORAGING ECOLOGY

The Yemen Linnet's diet consists primarily of a wide variety of seeds from low-growing plants and bushes, as well as occasional flower buds. It has been recorded foraging on the seeds of grasses, crops (wheat, barley, sorghum), shrubs (*Plectranthus barbatus*), herbs (*Rumex sp.,* and *Achyranthes sp.*) and other flowering plants. It forages almost entirely on the ground, usually amongst vegetation but also in areas of bare rock and soil. It occasionally perches on a plant to eat the seed, or reaches up from the ground to pull seed heads from grass. When not feeding, it usually perches in nearby bushes and trees. It regularly comes to the ground to drink.[446]

THE YEMEN LINNET OCCURS IN THE 'ASIR MOUNTAINS GENERALLY ABOVE 1,800 M, SOUTH FROM AROUND TAYIF.

A MALE YEMEN LINNET. MALES SING FROM PROMINENT PERCHES TO ATTRACT FEMALES AND TO INTIMIDATE RIVAL MALES.

Yemen Linnets form quite large foraging flocks of up to 60 individuals that wander the highlands in search of available seeds, before roosting communally in trees and bushes.

In the non-breeding season, Yemen Linnets form quite large foraging flocks of up to 60 individuals that wander the highlands in search of available seeds (sometimes using more barren areas, including the eastern fringe of the highlands), before roosting communally in trees and bushes. Foraging flocks of Yemen Linnet are sometimes joined by Yemen Serin or less often Arabian Serin.[447]

BREEDING BIOLOGY

There have been no detailed studies of the breeding behavior of Yemen Linnets. Nonetheless, by piecing together snippets from the scant reports, it appears that song is an important aspect of mate choice in this species. First, only the male sings – and what a sweet tinkling song it is. With its rapid melodious twittering interspersed with fluty notes, buzzing, and high-pitched trills, it is musical and variable and rich and lively and fantastic!

Second, the song is most often heard in the first half of the breeding season, from February to April.[448] Because singing is energetically costly, males will sing frequently only if there is potential benefit in doing so – in this case, the chance to reproduce. Equally, because singing is costly, female Yemen Linnets can assess male quality by measuring certain aspects of the male's song, such as song rate, loudness and repertoire size.

Third, the song is usually sung from a high perch, presumably to advertise to as many females as possible, in bursts generally lasting 10–30 seconds with a 5–7 second pause between songs, although in one instance a male was observed singing continuously for ten minutes without a break. Males will also sing in flight and when pursuing a female or when simply perched near one.[449]

A FEMALE YEMEN LINNET. BECAUSE SINGING IS COSTLY, FEMALES CAN ASSESS MALE QUALITY BY MEASURING SONG RATE, LOUDNESS AND REPERTOIRE SIZE.

Finally, several males often compete with one another by singing their songs at the same time. In one observation, two males were observed singing from the same bush. The singing birds held their slightly drooping wings out from their body and partially spread their tail, thereby revealing the white feathers on the wing and tail, thus making the display a visual one as well as an acoustic one. Eventually one bird flew – still singing – to another bush only to be followed by the other male to continue their song contest. When a female appeared, one of the males performed a circular song flight, singing continuously as it traced a 20-meter circle around the female.[450]

The observation of a song contest between rival males in which birds overlapped songs is especially interesting. When one male sings, a rival male can respond in one of three broad ways: (i) he can choose not to respond; (ii) he can sing only after the first male has stopped singing; or (iii) he can sing at the same time as the other male. In many songbirds, overlapping the song of a rival is a far more threatening gesture than alternating songs or not singing at all.[451] The fact that both of the male Yemen Linnets in the song battle mentioned above escalated their contest to include a visual display and continued from tree to tree suggests that these two birds were quite evenly matched.

Females can gather important information about the relative quality of competing males by eavesdropping on these male–male singing contests. In other finch species, experiments have demonstrated that females prefer to mate with males that sing the *overlapping* song rather than males that sing the *overlapped* song.[452] Further, females will invest more energy in reproduction when they are partnered with a male that sings the overlapping song – in captivity, female canaries that were exposed to broadcasts of overlapping songs laid larger eggs with more yolk (and thus produce stronger chicks) than females exposed to broadcasts of overlapped songs.[453] What's more, in some species the female is more likely to be unfaithful if she has recently heard her partner's song overlapped by another male.[454]

Although male Yemen Linnets sing more at the start of the breeding season, they nonetheless still sing throughout most or all of the year, though at a much-reduced rate. This suggests that males also use song to maintain year round territories by frequently reminding neighboring birds that "this territory is occupied".

Once pairs have formed and territories have been established, Yemen Linnets settle into the business of producing offspring. They appear to nest in solitary pairs or perhaps in very loose colonies. All nests discovered to date (around 20) have been built 1.4–5 meters above ground, usually on the outer branches of juniper trees or next to the main trunk. However as Yemen Linnets clearly also breed in areas without juniper forest, they must be able to nest in other tree species as well. The nest is a rather compact cup (about 8 centimeters in diameter with an inner cup around 4.5 centimeters wide), made from small twigs, grasses, rootlets, lichens and moss. The outside of the nest is decorated with cobwebs and lichens, presumably to aid with camouflage or nest insulation. In some nests, the beard-like Hanging Tree Lichen is attached to the edge of the nest forming a screen. The nest is generously lined with animal hair, fine grasses, and plant down.[455]

Females gather important information about the quality of males by eavesdropping on male singing contests. Females prefer males that sing an overlapping song rather than males that have their song overlapped.

Clutch size is 3–4 eggs, which are dull white or very pale blue with a few cinnamon-colored spots and thin streaks at the larger end.[456] The eggs are laid on successive days and incubation commences once the clutch is completed so the eggs hatch synchronously. The female builds the nest, sometimes with the male nearby. He may occasionally collect cobwebs for the nest. The female incubates the eggs either alone or with some minor assistance from the male.[457] The incubation period has never been measured, but is likely to be around 12 days (based on other finches of similar size). The hatchlings are likely to remain in the nest for around 13 days. Both parents care for the young in the nest and after fledging. The apparently long breeding season and the fairly small clutch size suggest that this species may be double brooded.[458]

CONSERVATION STATUS

The estimated global population of Yemen Linnets numbers 200,000 annual breeding pairs. Around half of the global population occurs in Saudi Arabia, making it one of the most abundant endemic species in the Kingdom (*see* Table 1). Accordingly, the species is listed as not threatened by the IUCN. The loss of the species' preferred juniper and acacia habitat through land clearing is likely to have an adverse effect on the species, though it frequently occurs in cultivated areas and thus may actually benefit from some human activities. Accordingly, the IUCN has listed the population as stable in the absence of evidence for any declines or substantial threats.[459] Yemen Linnets occur in at least two protected areas in Saudi Arabia: Rayda Reserve and 'Asir National Park.

On one occasion a male was observed singing continuously for ten minutes without a break.

A YEMEN LINNET TAKES FLIGHT FROM A JUNIPER TREE AT JABAL SAWDA', THE HIGHEST POINT IN SAUDI ARABIA.

ARABIAN GREEN BEE-EATER: NEAR-ENDEMIC TO THE ARABIAN PENINSULA.

ARABIAN GREEN BEE-EATER (*MEROPS CYANOPHRYS*)

Very few birds are as beautiful and as elegant as the Arabian Green Bee-eater. These exquisite birds are a photographer's dream: their sweet *"prrrit prrrit"* call makes them easy to find; they allow a respectful observer to approach reasonably close; they generally remain still on one of their favorite perches in between vibrant foraging bouts; they often sit side by side, pressed against their partner and young; and they are as interesting as they are pretty.

When Western scientists first discovered bee-eaters in Arabia in 1860 near al-Qunfudhah (in the southwest of Saudi Arabia) they assumed these gorgeous birds belonged to the same species as similar-looking bee-eaters found in tropical Africa and southern Asia. Thus, for the next 150 years the Arabian, African and Asian bee-eaters were lumped as one species, which was known simply as the Green Bee-eater (*Merops orientalis*). However, recent morphological analyses suggest that the Arabian, African and Asian populations are in fact three distinct species, which are now known as the Arabian Green Bee-eater (*M. cyanophrys*), the African Green Bee-eater (*M. viridissimus*) and the Asian Green Bee-eater (*M. orientalis*), respectively. The Arabian Green Bee-eater differs from the other two in having a bright azure-blue forehead, a cerulean-blue throat, a bluer lower belly, a broader black breast-bar, and a much longer tail (with very short stub-ended central tail feathers). The Arabian Green Bee-eater is also slightly larger than the other two species.[460]

Arabian Green Bee-eaters belong to the Meropidae family, known simply as the bee-eaters. The largest genus, *Merops*, contains 28 species, including the Arabian Green Bee-eater. Most *Merops* bee-eaters occur in Africa and tend

THE ARABIAN GREEN BEE-EATER IS FOUND THROUGHOUT MUCH OF THE WESTERN THIRD OF THE KINGDOM AND INTO THE CENTRAL REGION, PARTICULARLY IN WADIS.

to be sedentary species, while others are found across Europe, southern Asia and Australia and tend to be long distance migrants. Cooperative breeding (whereby pairs are sometimes supported by one or more "auxiliaries birds" that help dig the nest burrow, incubate the eggs, tend the young and defend the nest) has been reported in at least 10 species of bee-eaters,[461] including Asian Green Bee-eaters.[462] These helpers are usually the sons from a previous nest attempt, though in some cases daughters may also help.[463] To date, Arabian Green Bee-eaters have not been formally reported to enlist a helper at the nest. However, there are informal observations of trios attending nests near al-Makhwah in the 'Asir Province.[464] Given the propensity for helping in *Merops* bee-eaters, birdwatchers in Saudi Arabia should look out for (and report) instances of cooperative breeding in this species.

Around 99% of Arabian Green Bee-eaters occur in Saudi Arabia, Yemen, Oman, and the UAE. The remainder occurs between western Jordan and the eastern Sinai Peninsula, having spread into those areas in the 1960s following agricultural development, with vagrants recorded in Bahrain, Qatar, Iraq and Greece.[465] Sporadic records of green bee-eaters in the Arabian Gulf may be Asian Green Bee-eaters dispersing from southern Iran.[466] Two subspecies of Arabian Green Bee-eater are recognized, and both occur in Saudi Arabia: *M. o. cyanophrys* breeds in the west of the Kingdom, while *M. o. muscatensis* occurs in the center.

HABITAT

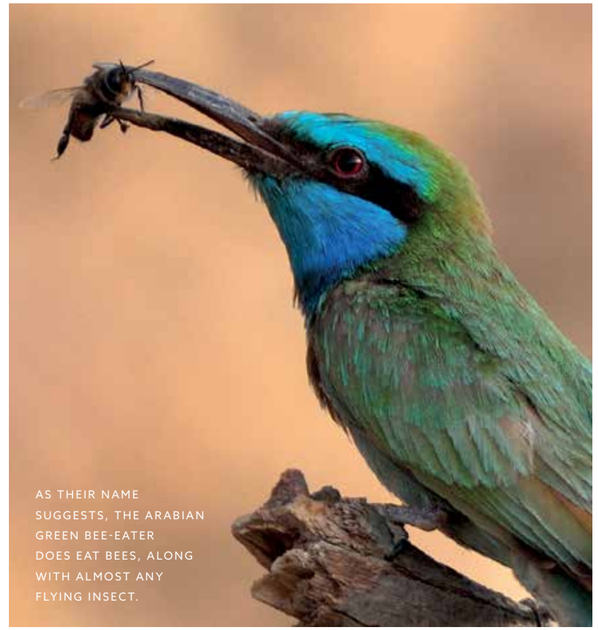
In Saudi Arabia, the Arabian Green Bee-eater occurs across much of the western third of the Kingdom and into the central region. It is found from sea level to 2,800 m. Within this vast area, these elegantly-colored birds occur wherever they can find: (i) vertical banks of earth or sand of an appropriate consistency into which they can their excavate long nest burrows without risk of collapse, and (ii) plenty of flying insects to eat. They prefer open habitat so that they can see, pursue and capture their mobile prey. These needs are met most often around rocky wadis with scattered acacia trees. Indeed this species is one of the most typical birds of Arabian wadis. They are also found on productive coastal plains, parklands, mountainsides, semi-desert areas, cultivated areas (including fields of Alfalfa) and wetlands.[467] They do not occur in hyper-arid environments since these areas usually do not contain sufficient numbers of flying insects or suitably compacted sand.

Although Arabian Green Bee-eaters are generally sedentary, there may be some seasonal movements within Arabia. Some birds nesting in the central region may wander south in winter, while birds nesting in alpine regions may move to areas below 1,800 m.[468]

FORAGING ECOLOGY

Arabian Green Bee-eaters prey upon virtually any day-flying insect, ranging in size from tiny Fruit Flies to large dragonflies up to 80 millimeters long, including an array of potentially hazardous items such as brightly-colored (and therefore probably distasteful) butterflies, blister beetles, malodorous bugs, dangerous wasps, and formidable hornets.[469] In one brief study of Arabian Green Bee-eaters nesting in the UAE, about 95% of prey brought to the nest consisted of bees, wasps and flies, while the remainder included moths, butterflies and grasshoppers.[470] They have also been observed eating dragonflies, beetles, locusts and ticks.[471] They occasionally supplement their diet with food taken from the ground.[472] Thus, ants could conceivably be an important component of the diet of Arabian Green Bee-eaters as has been reported for the closely related African Green Bee-eater.[473] All bee-eaters are known to forage on the ground – not for food but for small grains of sand, snail shell or pieces of quartz to help mechanically digest their food.[474]

Very few birds are as beautiful and as elegant as the Arabian Green Bee-eater. These gorgeous birds are a photographer's dream.



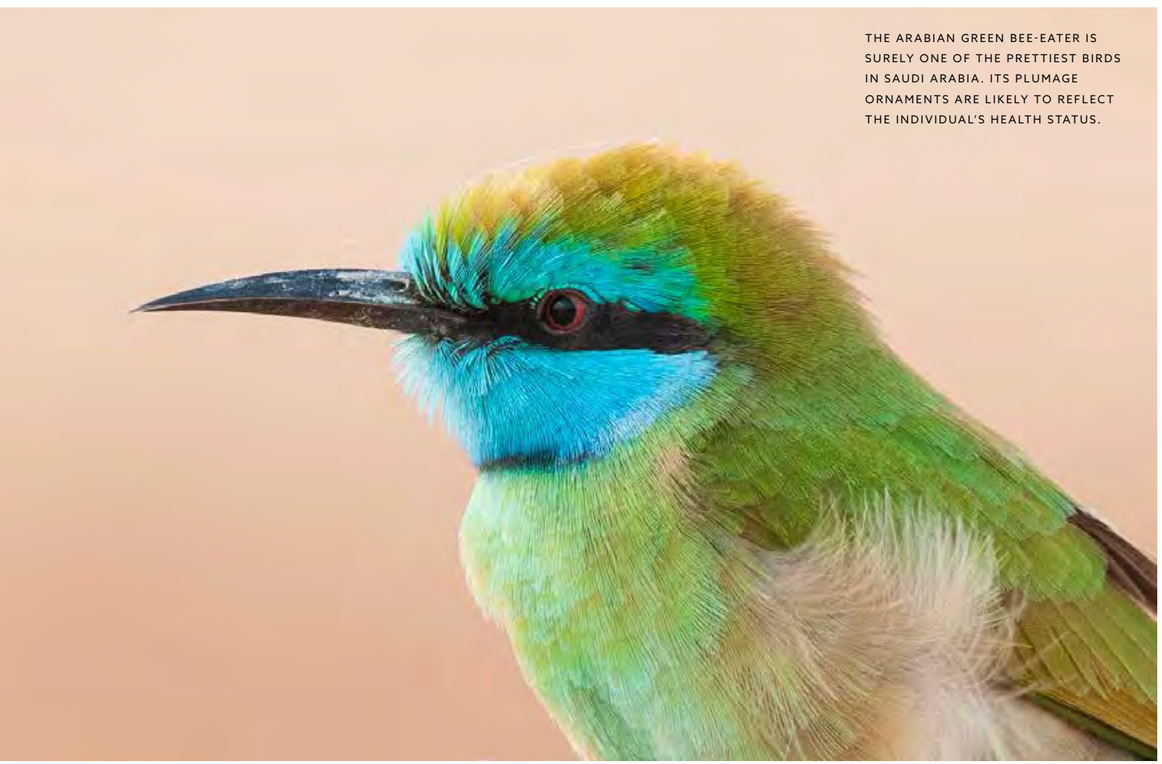
AS THEIR NAME SUGGESTS, THE ARABIAN GREEN BEE-EATER DOES EAT BEES, ALONG WITH ALMOST ANY FLYING INSECT.

Watching Arabian Green Bee-eaters foraging is an unforgettable experience – no insect can fly fast enough to escape a bee-eater in hot pursuit.

Since insect activity is strongly impacted by air temperature, Arabian Green Bee-eaters perch out in the open for most of the day, even during summer, enduring high temperatures that would be harmful or perhaps even fatal to many other animals. They often occur in stony areas containing no water where air temperatures regularly exceed 45°C and occasionally reach 50°C.[475] In periods of extreme heat, Arabian Green Bee-eaters reduce their core body temperature by seeking shade, panting with an open bill, and sitting with the body held high to expose the featherless inner thighs. Conversely, bee-eaters do not tolerate daytime temperatures much below 21°C for any sustained period. They obtain their water needs from their insect food, and do not drink.[476]

Watching an Arabian Green Bee-eater forage is an unforgettable experience. Scanning constantly from one of its favorite perches, these remarkable birds can detect prey from 70–100 meters away. As soon as they see a potential target they launch themselves into the air and charge after their prey with rapid wing beats. No insect can fly fast enough to escape a bee-eater in hot pursuit. In the blink of an eye, the bird swoops upwards or swirls around acrobatically to seize the insect, catches it in the tip of its slender bill with an audible snap, and then ambles gracefully back to the perch to enjoy the spoils. Each individual makes hundreds of pursuits per day, with about one foray in three being successful.

One of the most extraordinary aspects of bee-eaters is the way they handle their often-venomous prey. After returning to its perch with, say, a live bee, the bird quickly maneuvers the insect in its bill, grasping it crosswise just behind the thorax. It then leans to one side and forcefully bashes the insect's head against the perch a few times, thereby delivering it a fatal blow. However, a dead bee's sting is still venomous, so the bee-eater once again adjusts its grip, this time holding the bee by the abdomen, leans to the opposite side and rubs the bee's tail rapidly against the perch to remove the sting. The bee-eater keeps its eyes closed to protect itself against any venom that might squirt from the bee's tail. The bird bashes the insect's head against the perch a couple more times for good measure, then almost nonchalantly flicks the bee into the air, tilts its head back, catches the bee in its bill and swallows it whole. The whole foraging sequence – from detecting an insect to swallowing it – usually takes a matter of 10–20 seconds, and is performed with such poise and panache that it sometimes seems as if the bee-eater is waiting for a round of applause.



THE ARABIAN GREEN BEE-EATER IS SURELY ONE OF THE PRETTIEST BIRDS IN SAUDI ARABIA. ITS PLUMAGE ORNAMENTS ARE LIKELY TO REFLECT THE INDIVIDUAL'S HEALTH STATUS.

The oesophagus and stomach of adult bee-eaters usually contains numerous bee stings, indicating the "bee-rubbing" process is not always effective. Interestingly, a single bee sting probably contains enough venom to kill most small birds (and mammals) the size of an adult Arabian Green Bee-eater. Thus bee-eaters must have some physiological immunity to the poison that allows them to consume bees and other such dangerous prey items, including the exceptionally toxic (and rather terrifying) hornets that bee-eaters regularly eat.[477]

BREEDING BIOLOGY

Although the breeding biology of Arabian Green Bee-eaters has not been studied in detail, we can infer a great deal of information based on work conducted on other birds with similar attributes. For example, the elongated central tail feathers of Arabian Green Bee-eaters are likely to be sexual ornaments used in mate choice. This is because such tail streamers are an aerodynamic handicap: streamers extending from the center of the tail produce drag, and the longer they are the more drag they produce. Thus, only high quality birds are able to overcome the aerodynamic handicap associated with having especially long tail streamers.[478] Accordingly, in several species of bee-eaters sexual selection has resulted in the tail streamers being longer in males than in females,[479] though this has not yet been quantified in Arabian Green Bee-eaters.

The iridescent blue and black plumage around the face may also be an important signal of individual quality likely to be used in mate choice in this species. The biochemical pathways involved in producing this magnificent blue and black plumage require the presence of testosterone, which actually suppresses the immune system. Thus birds with more intense blue coloration in their plumage are effectively advertising that they must have great genes if they can overcome the burden of having additional testosterone circulating though their bodies.[480]

Once pairs have formed they maintain a long-term territory, possibly lasting all year round in many cases. Ideally the territory is large enough to provide a sustainable supply of flying insects, but small enough for the pair to be able to defend it. In one brief study from the UAE, breeding pairs obtained all food for their chicks from within 100 meters of their nest-site,[481] suggesting that territory size is roughly 3 hectares, at least during the breeding season.

Both members of the pair contribute to all stages of nesting, including nest building, incubation, chick rearing, and nest defense. Pairs excavate the nest burrow into a bank of compact sand, silt or earth (including banks only 20 centimeters high).[482] The tunnel is excavated by dislodging compacted earth or pebbles with the bill, followed by short, furious bursts of digging with the feet while leaning against the wall of the nest tunnel. This quite comical bicycling action can flick sand up to 50 centimeters behind the bird, sometimes resulting in a heap of soft sand on the bank below the nest entrance. Over a period of 2–3 weeks the pair steadily removes around 7–12 kilograms of sand or earth (up to 600 times the weight of the bird) to create a nest tunnel that is about 65 millimeters in diameter and up to 1.8 meters long. At the end of the tunnel the pair excavates an ovoid nest chamber around 15–30 centimeters long, which is left unlined. Excavating a nest tunnel is an arduous task and can wear down a bee-eater's bill by about 2 millimeters.[483] However, the exertion is well rewarded: nesting underground provides a stable, optimal microclimate for raising chicks, despite variations in air temperature above ground.[484] While ground temperatures in the hot Saudi Arabian sun may exceed 70°C, the bee-eater's nest chamber remains around 25°C.

Nest site selection is exceptionally important in bee-eaters since a tunnel collapse would be disastrous for any bird caught underground. Accordingly, bee-eaters choose sand banks with specific physical properties, based on particle size and compaction level.[485] They almost always excavate a new nest burrow each year and will often abandon a burrow before it is completed, presumably because of some structural defect. Consequently, a single territory may contain several unused nest tunnels. Identifying the active nest is usually quite simple as two little tracks develop along the bottom of the nest tunnel caused by the adult's feet scurrying repeatedly in and out of the nest. It's adorable.

The only nest of an Arabian Green Bee-eater to have been investigated (near al-Makhwah, 'Asir Province) contained four eggs,[486] which is a typical clutch for a bee-eater (clutch size from 16 sedentary African bee-eater species usually varies from 2–5 eggs and averages about 3.3 eggs).[487] The four eggs all hatched and all survived to fledging.[488]

The bee-eater's delicate, elongated central tail feathers are sexual ornaments used in mate choice, while the iridescent blue and black plumage is also an important signal of individual quality.

ARABIAN GREEN BEE-EATERS LAY THEIR EGGS AT THE END OF A NEST TUNNEL UP TO 1.8 M LONG, WHICH IS BUILT BY BOTH ADULTS.

Nesting in total darkness, there is no need for egg ornamentation or camouflage: thus Arabian Green Bee-eater eggs are pearly white. Based on the nesting behavior of sedentary African bee-eaters, incubation in Arabian Green Bee-eaters is likely to take between 18–21 days with the female contributing significantly more to incubation.[489] In some bee-eaters, females may remain under ground in the nest incubating for intervals lasting 90 minutes or more.[490]

The nestling period is likely to last around 30 days.[491] In Arabian Green Bee-eaters both parents bring food to the nest.[492] In the days prior to fledging, the weight of a well-fed bee-eater chick can exceed 20% of adult bird weight before steadily tapering off to be 1–2 grams (10%) above adult weight at fledging.[493] The chicks remain totally dependent on the adults for food for 2–3 days after fledging and then gradually develop sufficient hunting skills to achieve foraging independence after 2–3 weeks. Ringing studies of African bee-eaters indicates that some birds live for at least 7 years in the wild.[494]

Although many bee-eater species will lay a replacement clutch if the first nest is destroyed early in the attempt (e.g., due to predation or flooding), no bee-eater species has been clearly demonstrated to be double brooded.[495] Thus, a report of possible double brooding in Arabian Green Bee-eaters from a brief study of unbanded birds in the UAE[496] needs to be corroborated with further evidence.

Nesting underground has some fascinating consequences for the breeding behavior of bee-eaters. First, by creating a nest chamber at the end of a long narrow tunnel, the parents have effectively built a competitive arena in which the chicks must battle with their siblings for access to the nest tunnel. The chick that can dominate the nest tunnel gets first access to any food brought to the nest by the parents. Interestingly, the adults make the competition between the nestlings highly uneven by creating a distinct size hierarchy within the brood. The adults achieve this by laying their eggs at 1–2 day intervals, while starting incubation after the *first* egg is laid, causing the eggs to hatch in 1–2 day intervals. (If the parents began incubating the clutch after the *last* egg was laid, then all eggs would hatch synchronously). Thus in a brood of five, the oldest chick can be 10 days old by the time the fifth egg hatches. Consequently, the older, larger, more developed chicks are far stronger and far more competitive in the nest than their blind and naked younger siblings. Tiny infrared cameras inserted into the nests of Rainbow Bee-eaters (*M. ornatus*) in Australia show that siblings physically and aggressively compete for access to the nest entrance, pecking at each other or pulling one another by the tail or wing. Large chicks usually monopolize the nest tunnel and therefore obtain a greater share of food forcing the parents to work harder if they want to feed the smaller younger chicks. Consequently, many later hatched chicks die of starvation if insufficient food is available. This can occur, for example, if the nest is located in a poor territory or inclement weather prevents insects from flying for long periods.[497]

Another important consequence of nesting underground is that although the nest is protected from aerial predators (such as falcons and owls), it is nonetheless highly vulnerable to small ground predators, such as snakes, lizards and rodents, as well as larger predators like dogs, Honey Badgers, Striped Hyaena, Golden Jackals and Sand Monitors, which are all quite capable of digging a gaping hole along the entire length of the nest tunnel in order to eat the eggs, chicks or adults. While a bird that is nesting above ground can flee if it detects an oncoming predator, a burrow-nesting bird like a bee-eater has no chance of escape if it is in the nest when a predator arrives. It is doomed. Thus, for the entire nesting period, Arabian Green Bee-eaters risk their lives every time they enter their nest tunnel.

Bee-eaters manage the risk of nest predation by being hyper-aware of predators before entering a nest. First, nesting adults spend more than half of their time within 10 meters of the burrow entrance scanning for predators. If a bee-eater detects a nest predator, it will usually harass it with repeated dive-bombing flights in an effort to evict it from the territory. Second, a series of experiments in the Asian Green Bee-eater (which is very closely related to the Arabian Green Bee-eater) has demonstrated that bee-eaters have the extraordinary ability to understand their landscape *from the perspective of the predator*. For example, an adult bee-eater is unlikely to enter its nest if a predator is looking at the bird, and even less likely to enter its nest if the predator is looking at the *nest*, but it will enter a nest if the predator is looking elsewhere, which demonstrates that bee-eaters understand the significance of the direction of gaze of a potential predator.[498]

By creating a nest chamber at the end of a long narrow tunnel, the parents have effectively built a competitive arena in which the chicks must battle with their siblings for access to food.

Further, adult bee-eaters are much more likely to enter their nest if the predator *cannot* see the nest (for example if the predator's view of the nest is obscured by a bush), which demonstrates that bee-eaters understand the landscape from the visual perspective of the potential predator. Finally, bee-eaters are very reluctant to enter their nest in the presence of a predator that has previously seen the nest, even if the predator has subsequently moved to a position where it can no longer see the nest, which demonstrates that bee-eaters can assess not only what a predator can see at any precise moment but also what the predator has seen previously and what the predator therefore probably still *knows*.[499]

In short, a nesting bee-eater manages its high predation risk by adjusting its behavior according to its understanding of the predator's mental state and prior experiences, an ability that has been demonstrated in only a few other animals, including some primates, dolphins, elephants and dogs.

A nesting bee-eater manages its high predation risk by understanding the predator's mental state and prior experiences, an ability that has been demonstrated in only a few other animals, including some primates, dolphins, elephants and dogs.

CONSERVATION STATUS

The global population of these wonderful birds is tentatively estimated at about 150,000 annual breeding pairs. Around half of the global population nests in Saudi Arabia (*see* Table 1) where it can be locally common across a wide range of habitat types. The IUCN lists the Arabian Green Bee-eater as least concern due to the healthy population size, which is spread over a very large range. The global population is listed as increasing as agricultural expansion and irrigation creates new areas of suitable habitat.[500] Arabian Green Bee-eaters nest in good numbers in several protected areas across western and central Saudi Arabia.

NESTING UNDERGROUND PLACES ADULT ARABIAN GREEN BEE-EATERS AT GREAT RISK OF PREDATION. TO OVERCOME THIS, BEE-EATERS MAKE SHREWD DECISIONS ABOUT WHEN TO ENTER THEIR NEST TUNNEL.

ARABIAN LARK (*EREMALAUDA EREMODITES*)

The Arabian Lark is supremely adapted to life in the extreme desert climate of Saudi Arabia. This nomadic, inconspicuous, sandy-colored little bird occurs in remote areas across the Kingdom's sandy gravel deserts. It is nomadic and irruptive, meaning that it can appear locally abundant after rainfall, but then it seems to disappear entirely soon after. It is so unobtrusive that few people ever see it and almost no one has photographed it.

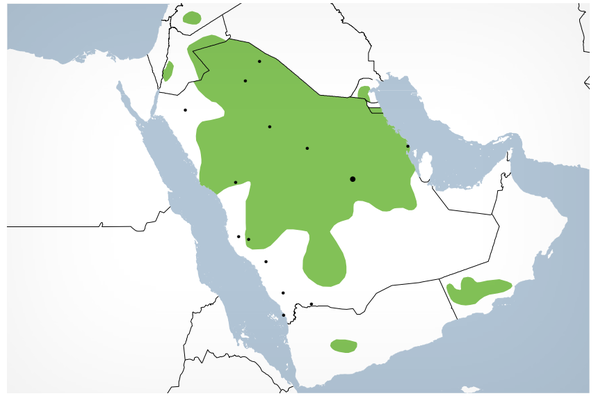
Until recently, the Arabian Lark was considered to be the same species as Dunn's Lark, which ranges from the southern edge of the Sahara through the Sahel Zone to central Sudan. However, birds in the Arabian population are much larger than birds in the African population, with a stronger, darker facial pattern, darker streaking in the crown, and a more rufous, grey-toned ground color in the upper body feathers.[501] Thus the African and Arabian populations have now been divided into two separate species.

The Arabian Lark belongs to the Alaudidae family (known simply as the Larks), which contains 92 species in 21 genera. The taxonomy of the lark family has undergone major revisions as a result of recent genetic analyses[502] with the Arabian Lark and Dunn's Lark now regarded as the only members of the genus *Eremalauda*.

Splitting the African and Arabian populations into two distinct species means that the Arabian Lark is nearly endemic to Arabia. The bulk of Arabian Lark population occurs in Saudi Arabia with smaller populations in Yemen and southwestern Oman. As it is a somewhat nomadic species, irregular and sporadic populations have been reported in Jordan, UAE, Kuwait, Lebanon, Qatar, Syria and northeastern Sinai Peninsula.[503] Nonetheless, the vast majority of the species breeds within the Arabian Peninsula and hence the Arabian Lark is included here as a near endemic species.

HABITAT

In Saudi Arabia, the Arabian Lark has a widespread distribution across most of the center and north of the Kingdom, particularly between 22–28°N (roughly between Hayil and Makkah). It occurs from sea level up to 1,200 meters in either flat or undulating terrain. It prefers open, undisturbed, remote plains composed of gravel or compacted sandy soils with a variety of shrubs, grasses and annual plants. It is often found around wadis with sparse dry herbaceous cover. It avoids the Kingdom's highlands, rocky slopes, areas with dense bushes, and extremely arid sand seas. It also avoids human settlements and cultivated fields.[504]



ARABIAN LARK: NEAR-ENDEMIC TO THE ARABIAN PENINSULA.

The species is nomadic outside of the breeding season, wandering the deserts in search of suitable habitat (usually in response to local weather conditions) typically in small flocks of up to 20 birds. It sometimes flocks with other larks, particularly Bar-tailed Lark and Rufous-capped Lark. It leaves areas that have experienced prolonged drought to search for sites that have benefited from rainfall. This wandering can bring periodic irruptions of Arabian Larks into areas outside of its normal range.[505]

THE ENIGMATIC ARABIAN LARK OCCURS IN REMOTE PLAINS ACROSS THE CENTER AND NORTH OF THE KINGDOM.

THE ARABIAN LARK SOMETIMES EATS GREEN VEGETATION TO SUPPLEMENT ITS MAINLY INVERTEBRATE DIET. THESE BIRDS MIGHT OBTAIN ALL THEIR WATER FROM THESE FEW PRECIOUS GREEN SHOOTS.

Arabian Larks possess exceptional physical and behavioral adaptations that enable them to withstand the intense sunlight and heat of the open arid deserts of Saudi Arabia.

Arabian Larks employ shrewd methods of keeping cool, spending much of their time sheltered in the deep burrows of Dhub (Spiny-tailed Lizards) or resting on cool Desert Gourds.

FORAGING ECOLOGY

There are very few records of the diet of the Arabian Lark. The scant reports suggest it has a typical lark diet of small seeds and invertebrates up to the size of a grasshopper. Adults of other well-studied lark species take green vegetation as a secondary component in their diet, as well as small bulbs and fruits, which collectively may be important sources of water in the diet. In nearly all lark species, the nestlings are fed exclusively on invertebrates, and adult Arabian Larks have likewise been observed feeding caterpillars to their chicks. Arabian Larks forage on the ground, usually singly or in pairs (or in small flocks outside the breeding season). Individual birds will dart about anxiously, pause briefly, and then scurry off again in search of food. They will also dig in the sand with their bill and fossick amongst low vegetation for insects.[506]

In Saudi Arabia, foraging on the ground in the open desert exposes the bird to intense sunlight and heat from above as well as considerable heat radiating from the desert floor below, which can exceed 80°C. Such high temperatures and intense solar radiation can be lethal to a small bird. However, Arabian Larks possess a suite of physical and behavioral adaptations that allow them to survive in such an unsympathetic environment.

First, unlike larks from temperate environments (which are usually brown or fawn colored), the upper parts of the Arabian Lark are the color of sand, which not only provides camouflage in its desert terrain, it also reduces the amount of heat absorbed from the sun. Further, the underparts are almost white below, which again reduces the amount of heat absorbed from the sandy substrate upon which they forage.

Second, Arabian Larks are exceptionally good at finding ways to avoid sunlight. When the weather is hot, virtually all of their foraging activity occurs in the early morning and late afternoon. The rest of the day is spent sheltering in trees and bushes, perched strategically so that their body is in shade and, ideally, away from the heat radiating from the baking earth below. In fact, Arabian Larks value shade so highly that they often allow people to come within 3–5 meters before they reluctantly fly away in search of another shaded location.[507]

Arabian Larks also employ other more shrewd methods of keeping cool. For example, they often spend much of their time sheltered in the deep burrows of Spiny-tailed Lizards, which can be 8°C cooler at the entrance and more than 20°C cooler deeper inside, thereby reducing the bird's water loss by over 80%.[508]

Furthermore, Arabian Larks have the canny ability to cool themselves by resting on certain plant species, such as Desert Gourd, which, because of its long taproots that reach into the water table, are at least 15°C cooler and considerably more humid than the surrounding air. Arabian Larks will interrupt their foraging bouts to lie flat on these mat-like green plants for minutes at a time. Sometimes several birds will rest on the one plant, each benefiting from the water vapor that slowly transpires through wide open pores (stomata) on the leaf surface, reducing the bird's body temperature through evaporative cooling in even the slightest breeze. Even when soil temperature reaches 70°C and ambient air temperature exceeds 54°C the temperature of Desert Gourd leaves do not exceed 41°C.[509]

The extreme heat of Saudi Arabian deserts means that small birds are at great risk of dehydration. To help mitigate this risk, Arabian Larks possess physiological adaptations that conserve the invaluable water reserves within their tiny bodies. In small birds, about 50% of water lost to the environment passes through the skin (a process known as cutaneous water loss). The main barrier to cutaneous water loss is the outermost layer of skin (called the stratum corneum), which is composed of flattened, dead cells embedded in a matrix of fats and oils (lipids). In Arabian Larks (and other desert species), the lipid matrix in this outer skin layer contains an unusual combination of cholesterol, fatty acids and other substances that bind together to prevent water from escaping across the skin's surface. Consequently, in an analysis of 20 lark species from across the northern hemisphere, Arabian Larks have the second lowest rate of cutaneous water loss. In fact, the five species with the lowest rates of cutaneous water loss are all larks from Saudi Arabia (Arabian Lark, Black-crowned Sparrow-lark, Crested Lark, Desert Lark and Greater Hoopoe-lark). Thus, despite foraging in extreme heat and aridity, the Arabian Lark loses about half as much water through the skin as similar-sized larks living in temperate environments. Interestingly, if a mammal had the combination of lipids in the skin that Arabian Larks possess, the mammal would suffer a debilitating condition known as Gaucher's disease. How Arabian Larks are able to overcome this problem remains a mystery.[510]

Arabian Larks are able to conserve water and tolerate extreme heat courtesy of their reduced metabolic rate, which is 43% lower than similar larks from temperate environments. This low metabolic rate ensures that all chemical processes in the body (such as respiration, digestion, etc.) occur more slowly than in other birds of their size, resulting in 27% less water lost through the breath and excretion and a body temperature that is 1.1°C lower than expected.[511] Furthermore, the metabolic rate of the Arabian Lark is flexible and adjusts to match its environment: as average daily air temperature increases from 15°C to 35°C throughout the year, the already low basal metabolic rate of Arabian Larks decreases by an additional 12%, which further reduces the amount of water lost during the summer. Astonishingly, the size and volume of the digestive organs also decreases (by about 25–30%) as the birds acclimate to the steadily increasing temperature, which further suppresses their need for food and water during periods of heat and hardship.[512]

BREEDING BIOLOGY

Male Arabian Larks face a dilemma. In order to avoid predation and reduce heat stress in the hot, open deserts of Saudi Arabia they must have pale and sober-colored plumage. Yet in order to attract a mate they must somehow make themselves conspicuous and attractive. They overcome this predicament with song. But therein lies another problem. Their open desert habitat contains very few if any trees from which to broadcast their song. Thus the solution is that Arabian Larks (and several other lark species) sing their magnificent song in flight. The male will rise to 30 m, sometimes even 50 m or more, above the ground, hovering with slow wing beats, swinging from side to side as it bursts forth with its song – a celebration of rapid chirping, rattling warbles and whistles. The bird rises and falls in the air as it alternates fluttering its wings and pausing, before eventually making a parachute-like glide back to earth, gently spiraling on open wings. These glorious song flights last for several minutes. Indeed, one bird was recorded singing continuously in flight for 13 minutes. To add to the display, some Arabian Larks mimic the calls of other birds, including that of other larks.[513] Although the repertoire of the Arabian Lark has not been quantified, some African lark species (e.g., Red-winged Lark *M. hypermetra*; Melodious Lark *M. cheniana*) have been demonstrated to imitate as many as 57 species from 20 different families of birds.[514]

The song flight of Arabian Larks is remarkable because it is an exceptionally costly thing to do. In birds, the most energy consuming activity is flight – particularly in hot weather. For many species, the second most energetic activity is song. Thus to sing in flight for up to 13 minutes in the hot spring of a Saudi Arabian desert requires extraordinary physical prowess. Little wonder that larks prefer to fly at minimum power speed during song flight[515] and then rest on the ground for some time after an extended bout.

Despite foraging in extreme heat and aridity, Arabian Larks lose about half as much water through the skin as similar-sized larks living in temperate environments.

The song flight of Arabian Larks is an exceptionally energetically costly activity. To sing in flight for up to 13 minutes in the Saudi Arabian desert requires extraordinary physical prowess.

THE WHITE BELLY OF THE ARABIAN LARK REDUCES HEAT ABSORPTION FROM THE BAKING GROUND. ITS SANDY COLORED UPPERPARTS PROVIDE CAMOUFLAGE FROM ABOVE.

THE PROBLEMS OF SURVIVING IN THE HOT SAUDI ARABIAN DESERTS ARE EXACERBATED DURING THE BREEDING SEASON WHEN ADULT BIRDS MUST SPEND MORE TIME FORAGING IN ORDER TO CARE FOR THEIR HUNGRY CHICKS.

Falcons know that a lark that is unable to sing well in flight is a weak bird and therefore a good target to chase.

Consequently, after spring rain the deserts of Saudi Arabia are infused with the sounds of larks in song. Female Arabian Larks are able to assess the quality of a male based on the duration of its song flight and perhaps the complexity of its mimicry. Weak males are simply unable to sing vigorously while flying for long durations. But it is not just the females that assess male quality by its song flight – predators too can judge a lark's individual quality based on the duration of the song. Interestingly, some larks sing when being pursued by falcons, presumably as a means of advertising their fitness to the predator in an attempt to dissuade it from the chase. Accordingly, studies of Eurasian Songlarks have shown that falcons are more likely to pursue individual larks that do not sing (or sing poorly) when chased.[516] That is, falcons know that a lark that is unable to sing well is a low quality bird and aerobically unfit and therefore a good target to chase.

Once territories have been established and pairs have formed, Arabian Larks turn their attention to nesting. A nest site is established on the ground beneath a low shrub or tuft of grass, which provides shelter from the worst of the heat. Arabian Larks excavate a small hollow in the ground in which they build a neat nest cup made of grasses and thin twigs, which in turn is lined with finer grasses, plant down and occasionally a few feathers. Unlike some other desert lark species, Arabian Larks do not build a pebble pavement or rampart around the nest.[517] However, some nests have a lining of small pebbles below the cup, the purpose of which is not clear; but if these pebbles heat up more slowly than the surrounding earth then they may help to control temperature in the nest during the hottest part of the day.[518] Although the role of the sexes in nest building is unknown, nest construction in most (but not all) other larks is generally by the female alone.[519]

The clutch consists of 2–5 eggs (usually 3 or 4), which are incubated mostly by the female.[520] As would be expected for ground-nesting birds, lark eggs are cryptically patterned for camouflage. In most larks, eggs are laid at the rate of one per day and incubation commences only after the last or penultimate egg has been laid resulting in synchronous hatching. The duration of the incubation period is unknown in Arabian Larks, but in most desert larks (such as the closely related Dunn's Lark) incubation is completed in 13–16 days (whereas temperate species require only 11–13 days).[521] The hatchlings quickly develop a sparse covering of pale-grey down on their upper surfaces.[522] As is the case for all lark species, both parents care for the nestlings and fledglings.[523]

The problems of finding food in the hot and sparse Saudi Arabian deserts are amplified once the eggs hatch for now the parents must also find food for their hungry nestlings. To compensate for the lack of food brought to the nest, Arabian Lark chicks (like their parents) have a particularly low metabolic rate. Consequently, compared to similar-sized larks in temperate environments, Arabian Lark offspring require almost 30% fewer calories and up to 50% less water to survive and grow. Further, since the adults themselves have less energy to devote to their offspring, Arabian Larks usually produce only 2–3 chicks per brood, whereas larks from temperate environments usually produce 4–5 chicks.[524]

Larks generally suffer from very high levels of nest predation. As an adaptive response, the chicks of most temperate lark species leave the nest once they are only seven or eight days old, which is essentially the most rapid rate of growth that is physiologically possible. However, the lack of food brought to the nest in desert environments means that Arabian Lark chicks are unable to grow quite as quickly. While the duration of the nestling phase has not been quantified in Arabian Larks, the chicks of the closely related Dunn's Lark leave the nest at about 10 days of age. Thus, the hatchlings of desert larks remain vulnerable to prowling nest predators for about 20% longer than is the case for their temperate counterparts.[525]

Fledglings are likely to hide in the vicinity of the nest for another 3–6 days until they can fly. The post-fledging period of care is relatively long in larks with the young taking almost a month to attain foraging independence.[526] Most Arabian Larks are likely to be single brooded, although there is some evidence of occasional double brooding,[527] presumably in response to unusually good foraging conditions.

Nesting on the ground in open habitats is an inherently risky activity as both the nest and the adults are exposed to ground predators (such as Sand Monitors, snakes and mammals) and aerial predators (particularly ravens, shrikes and raptors). To mitigate the high rate of nest predation, an Arabian Lark sitting on the nest will often attempt to lure an approaching predator away from the nest by performing a distraction display. The adult bird draws attention to itself by feigning injury while steadily walking away from the nest in a shuffling manner or while dragging and fluttering one wing as if it were broken. The bird may continue this ruse for up to 30 m, gradually enticing the predator from the vicinity of the nest before fleeing.[528] In other lark species, these distraction displays have been shown to become more frequent and more emphatic as the eggs or chicks develop because these parents have already invested so heavily in the nest.[529] Despite these tricks, nest mortality in larks is usually very high, particularly in arid environments where as many as 80–90% of nests are lost. Hence to overcome these exceptional rates of nest mortality, most larks have the capacity to replace their nest and commence re-laying within only 4–6 days of the predation event.[530]

A nesting Arabian Lark will often lure a predator away from the nest by pretending it has a broken wing: it slowly walks away from its nest while dragging one wing. Thus it attracts the predator to itself in order to save its young.

Since females do most or all of the incubation in larks, they are particularly vulnerable to nest predation. Indeed, predation of nesting

A RATHER BEDRAGGLED AND THIRSTY LOOKING ARABIAN LARK SEARCHES FOR FOOD IN THE BARREN NORTHERN PLAINS

During prolonged drought, Arabian Larks simply do not breed, which must have a significant impact on the lifetime reproductive success of a small bird that might experience only a few breeding events in its short life.

female Crested Larks (studied in the deserts of Turkmenistan) is so great that by the end of the breeding season males outnumber females by more than 4:1. Such skewed sex ratios against males have probably contributed to the development of the flamboyant aerial displays typical of male larks: in order to successfully compete for female attention, the male may need to perform particularly exuberant song flights.

In the deserts of Saudi Arabia, several months – indeed several years – can pass without a drop of rain. During these prolonged droughts there is just too little food available to meet the needs of growing nestlings. The adults cannot compensate by simply spending more time foraging because they would risk death from heat exhaustion. Instead, during drought Arabian Larks simply do not breed at all, which must have a significant impact on the lifetime reproductive success of a small bird that might experience only a few breeding events in its short life. However, when there are good rains in the Kingdom, Arabian Larks eat more food, rapidly increase the size of their digestive organs, elevate their metabolic rate and attempt to produce as many chicks as they can. They may not get another chance.[531]

CONSERVATION STATUS

Presumably because of its nomadic and irruptive nature, population size estimates for the Arabian Lark vary widely. On the one hand, few birdwatchers have ever seen the species. Yet on the other, some authorities have estimated the population of Arabian Larks to number as many as 1.7 million pairs in Saudi Arabia alone, which would make it the fourth most abundant breeding bird in the Kingdom (behind Desert Lark, Crested Lark and House Sparrow).[532] Given the dearth of recent records in Saudi Arabia, this figure seems to be a significant overestimate, perhaps calculated during a period of population boom in the Kingdom. A figure of 17,000 is used in this book (*see* Table 1), but this is little more than an educated guess. Around 85% of the population nests in Saudi Arabia.[533]

The IUCN lists the species as least concern on account of the potentially large population size and extensive range; further the species is listed as stable in the absence of any clear evidence of a decrease in population size.[534] However, the concerning absence of records in recent years suggests this assessment needs to be revisited. The dramatic impact of human activities on desert lark abundance has been quantified in Kuwait where lark abundance was 3–200 greater in protected areas than in surrounding non-protected areas, depending on the species.[535] Since the Arabian Lark shuns cultivated fields, the conversion of several million hectares of suitable habitat to agricultural development has probably had a detrimental effect on the population.[536] Fortunately, the species occurs in several protected areas in Saudi Arabia.

Studies of Arabian Larks and other desert larks conducted in Saudi Arabia indicate that a combination of superb behavioral and physiological adaptations to extreme heat and aridity allow this species to survive and breed in ambient temperatures that are at the very edge of the lethal maximum body temperature for birds – but only just. Any increase in average daily temperature could be disastrous for its survival, which would be a sad outcome because amongst all the hardship the Arabian Lark somehow finds the energy to sing an exquisite song that floats through the desert like a call to prayer and brings joy to all those lucky enough to hear it.

ARABIAN BABBLER:
NEAR-ENDEMIC TO THE ARABIAN PENINSULA.

ARABIAN BABBLER (*ARGYA SQUAMICEPS*)

The Arabian Babbler is, without question, one of the most interesting birds in the world. Long-term studies continue to uncover some of the most complex and fascinating social behavior ever recorded in birds. In fact this species has been studied continuously for over 45 years and the longer it is studied the more extraordinary it appears.

The Arabian Babbler belongs to the Leiotrichidae family (the laughing-thrushes and their allies), and the genus *Argya*, which contains nine species distributed throughout much of northern Africa and southwestern Asia. About 98% of Arabian Babblers occur in the Arabian Peninsula, while the remaining 2% can be found in a relatively narrow band from the eastern Sinai to western Jordan. Around half the world's population occurs in Saudi Arabia while other large populations are found in Oman, the UAE and Yemen. Three subspecies are recognized, two of which occur in Saudi Arabia: the bulk of the Saudi Arabian population is comprised of *A. squamiceps squamiceps*, while birds in the southwest are regarded as *A.s. yemenensis*. The third subspecies (*A.s. muscatensis*) occurs in Oman and the UAE.

HABITAT

In Saudi Arabia, the Arabian Babbler occurs along the western third of the kingdom (from Jordan to Yemen) and into the central region. It can be found at all elevations, from sea level to the highest peak at Jabal Sawda', though it is more common in the lowlands. Within this vast area it prefers acacia woodlands and other scrubby areas, such as wooded grasslands, gardens, and the shelterbelts around cultivated areas. It avoids open sandy deserts, barren mountains, rocky areas, forests and urban areas. It is distributed patchily in the northwest, with a more continuous range along the western provinces from around Umm Lajj and central Hayil south into Yemen.[537]

Arabian Babblers are primarily sedentary residents. However they appear to become increasingly rare over winter in the center of the Kingdom, which suggests there is some seasonal movement (as has been demonstrated in southern Oman where groups disperse into the desert during winter).[538]

FORAGING ECOLOGY

The diet of Arabian Babblers consists primarily of terrestrial invertebrates, including beetles, ants and wasps, ticks, crickets, ant-lion larvae, caterpillars, centipedes, moths and butterflies, spiders, grasshoppers, scorpions and termites. They supplement their diet with plant matter, including a range of berries, flowers, seeds (including sorghum and maize), nectar, and Rumex leaves. They will also opportunistically eat some small reptiles (such as lizards and even snakes up to 20 centimeters long), and perhaps small mammals. They are inquisitive birds and will sometimes eat scraps of bread and other picnic waste.[539]

Arabian Babblers forage amongst bushy cover either directly from the ground or in low undergrowth. Much of their time is spent busily digging with their bill, flicking over stones, and scratching amongst leaf litter in a seemingly desperate search for food. They also glean prey items off the foliage of bushes and trees, occasionally stripping bark or probing amongst branches.[540] Within each foraging group there is a strict dominance hierarchy based on years of social interactions (see below). And this is where things get really interesting...

BREEDING BIOLOGY

Arabian babblers live in stable groups of up to 23 birds (usually 6–13) on territories up to 1 square kilometer. Most groups consist of a single breeding pair and their offspring from previous years (although more complex group structures also occur, as discussed below). Unlike most other birds, young babblers do not disperse and look for a mate. Instead, they stay within their family's territory for many years and help their parents to raise more offspring. The young babblers help build and defend the nest, incubate eggs and feed and clean the chicks. As a result, larger groups produce more fledglings, which leave the nest at a healthier body weight and are more likely to survive to adulthood.[541] Thus, although helpers do not receive any of the direct benefits of reproduction, they nonetheless help to raise their younger brothers and sisters. This mating system is called cooperative breeding, and Arabian babblers are the most intensely cooperative birds in the world. Helpers are so important in this species that a pair of babblers is simply unable to produce a single offspring without them – a pair just could not find enough food for their young to survive. In other words, babblers are *obliged* to live in long-term social groups.

The Arabian Babbler is one of the most interesting birds in the world. Long-term studies continue to uncover some of the most complex and fascinating social behavior ever recorded in birds.

Because the offspring do not disperse, the group tends to grow larger with each passing year. Eventually, the babbler group will become large enough to split into two or more groups. A coalition of helpers will break away from the family to join another group of unrelated birds.[542] Suddenly, birds that have been helping for years now have the rare opportunity to become a breeding adult within this newly formed group – but only the highest quality bird within each coalition will earn the right to breed. In Arabian Babblers, individual quality is displayed and judged not by flashy plumage or ornamentation or body mass or strength, but by social rank determined by years of social interactions. For these reasons, much of a young babbler's behavior is aimed at embedding itself within a strong faction within its group, and advertising its quality to other group members through an amazing array of social behaviors. These behaviors are designed to ensure it will be the dominant bird whenever an opportunity to breed arises in the future.

One way that young babblers form alliances is through a wide range of social play, which can last for several hours each day. Sometimes two or more babblers will wrestle and roll around on their

Unlike most other birds, young babblers stay within their family's territory for many years and help their parents to raise more offspring. In other words, they breed cooperatively.

THE ARABIAN BABBLER OCCURS IN THE WESTERN AND CENTRAL REGIONS OF SAUDI ARABIA, PARTICULARLY WHERE ACACIA TREES ARE FOUND.

backs, trying to pin one another on the ground, or two babblers will jump head-on into each other trying to make the other one lose balance. Other games are known in the scientific literature as "king of the castle" (where the objective is to knock one of the birds off of a certain spot), "tug-of-war" (where two birds will pull at opposite ends of a feather or stick), or "crazy chase", which is one of the most common games, where birds will take turns chasing one another within an area up to three meters in diameter. As many as 13 birds have been seen playing crazy chase all at once.[543]

Arabian Babblers also develop social alliances by performing an intriguing "morning dance" several times per month. The dance starts around dawn when one group member stands near a bush in an open area and begins to preen itself with deliberate, jerky movements. One by one, other members of the group join in, until eventually they are all huddled together in a line. They then dance about each other changing positions and forming different clumping patterns, all the while preening themselves and each other with extravagant movements. The dance, which can last for over half an hour, eventually ends when the birds leave the parade one by one to begin their morning foraging bout.[544] The morning dance is one way that babblers can "show off" in front of other group members. Since babblers obviously cannot dance and find food at the same time, the individuals that dance the most are demonstrating that they are so healthy and so good at finding food they can afford to spend more of their time dancing.

In Arabian Babblers, individual quality is displayed and judged not by flashy plumage or ornamentation or body mass or strength, but by social rank determined by years of extraordinary social interactions.

Another way that a babbler can advertise its quality is by offering food to subordinate birds (a behavior called "allofeeding"). The bird delivering the food stands up tall and trills to emphasize its dominance, while the subordinate bird crouches low, flutters its wings, and sometimes makes a begging sound. Interestingly, if a subordinate refuses to accept the food offering, the dominant babbler punishes the subordinate by chasing and pecking it to reinforce its social status. Sometimes a subordinate will try to advertise its quality by offering food to a dominant bird – but this is a rookie mistake. A dominant bird will always refuse to accept food from an inferior, and again it will bolster its dominance by chasing and pecking the subordinate.[545]

A babbler can also show off its high quality by engaging in behaviors that benefit other group members, especially if the behavior is costly to itself. For example, since babblers usually forage on the ground, they are vulnerable to predation from mammals (such as foxes, cats, and wolves),

JUVENILE ARABIAN BABBLERS DELAY DISPERSAL. THEY REMAIN WITH THEIR PARENTS FOR MANY YEARS, HELPING TO PROTECT THEIR TERRITORY AND TO RAISE SUBSEQUENT NESTS.

birds of prey (hawks and falcons) and snakes. To reduce the risk of predation the birds usually forage in tight groups. Further, some members of the group will stand guard on a high exposed perch and look out for predators. When the sentinel sees a predator it makes an alarm call and the rest of the group responds, either by running for cover and scanning for the predator, or by flying to be with the sentinel to help look for the predator. Not only is the sentinel able to communicate that the group is under threat, it is also able to express the urgency of the threat. That is, the sentinel will "bark" if it sees an aerial predator that is far away, "trill" if the threat is intermediate, and "tzwick" if a predator is close by and danger is imminent. In this way, the group members can respond to the alarm call with an appropriate level of urgency.[546]

ARABIAN BABBLERS BUILD LONG TERM SOCIAL RELATIONSHIPS THROUGH PLAY, DANCING, SOCIAL FEEDING AND GROUP DEFENSE.

The sentinel behavior of Arabian Babblers is quite intriguing. Not only is the sentinel voluntarily giving up precious foraging time, it puts itself in a conspicuous position away from the rest of the group where it is more exposed to predation. Indeed, individuals actually compete with one another to perform the role of sentinel.[547] By acting as a sentinel the bird is proving that it is so good at foraging that it can afford to spend 30 minutes looking for predators. Sure enough, feeding experiments have shown that well-fed (i.e., higher quality) birds tend to spend more time being sentinels. Low quality, hungry birds simply cannot afford to stand guard; they have to spend all of their time looking for food. According to this hypothesis, by engaging in seemingly altruistic

AN ADULT ARABIAN BABBLER ASSUMES A SUBMISSIVE POSTURE WHEN BEING FED BY A DOMINANT BIRD.

AN ARABIAN BABBLER PROTECTS ITS GROUP MEMBERS BY STANDING ON AN EXPOSED PERCH AND SCANNING FOR PREDATORS – BUT THIS PLACES THAT INDIVIDUAL BIRD AT GREATER RISK OF PREDATION.

behavior the sentinel gains social prestige, which increases its chances of forming strong social alliances and winning the right to mate.[548]

Sometimes an alarmed group will form a "mob" to harass a potential predator. When mobbing a snake, babblers assume distinctive mobbing postures (such as neck-stretching, tail-spreading, wing-lifting, and wing-flicking); they move in circles around the snake and emit a special snake-mobbing call. This mobbing behavior can last for over ten minutes. The snake species most often mobbed by Arabian babblers is the Arabian Horned Viper, which tries to ambush unsuspecting birds that are foraging on the ground. Significantly, these vipers cannot climb trees and do not actively chase foraging babblers. Therefore, once detected, a viper presents no danger to a babbler. So why do babblers perform these elaborate, risky and energetically costly mobbing behaviors against a viper that has already been detected? By harassing and taunting a potentially lethal snake individuals can advertise their current physical condition, agility and evasiveness. Furthermore, by participating in a dangerous activity with others the bird is underlining its value as a coalition member. When mobbing a viper, babblers are actually competing with one another to perform altruistic behaviors to gain social prestige. In an effort to reassert its status a dominant bird will even chase and peck a subordinate bird as punishment for mobbing a snake for too long.[549]

Finally, helpers can augment their social status by helping at the nest – by bringing food, incubating and preening the chicks, and defending the nest. Actually, helping at the nest provides group members with both direct and indirect benefits. That is they benefit *directly* because helping at the nest is another ostentatious way of improving social status within the group.[550] Further they might also benefit *indirectly* because helping at the nest produces more siblings, which share 50% of their own genes.[551]

Following years of these extraordinarily complex social interactions a hierarchy is established within the group. At the onset of the breeding season, group structure may be (i) simple, with a single breeding male, (ii) multi-male, with several males competing for the dominant female, or (iii) complex, with several females and several males breeding together following the break-up and amalgamation of previous groups (for example after the death of a key group member or invasion from a neighboring group).[552]

The dominant pair within the group selects a nest site within their territory and builds the

Arabian Babblers develop alliances through social play, by "dancing" together, by spending time scanning for predators on behalf of the group, by feeding each other, and by helping at another bird's nest.

A NEST OF THE ARABIAN BABBLER IN A THORNY ACACIA. IN THIS REMARKABLE SPECIES, GROUPS OF UP TO 23 ADULT BIRDS MAY HELP RAISE THE CHICKS AT A SINGLE NEST.

nest, generally with limited assistance from their helpers. Only one nest is active in each territory at any given time. Most nests are built up to 2 meters above ground in thick bushes (especially acacia), but some are placed up to 5 meters high in the fork of a tree. The nest is a thick, bulky, untidy cup, composed mainly of dry grass, plant stems and bark with a twiggy base, lined with rootlets, animal hair and feathers.[553] Once the nest is complete, the female will lead the dominant male to a secluded place to copulate, but also to test the extent of his authority. If a second male follows the pair but is not challenged and driven away by the male, then the female knows that the first male is not in full control of the group, and she may copulate with the second male.[554]

Male Arabian Babblers often disperse by invading an adjacent territory. Generally the most dominant son leads the invasion, taking his younger male siblings with him to increase his chances of ousting the incumbent male.

The dominant female lays a clutch of usually 3–5 plain turquoise eggs.[555] In some nests, subordinate females lay additional eggs following sneaky copulations with the dominant male resulting in up to 13 eggs in the one nest. On average, clutches from multiple females are less successful than clutches from a single dominant female due to egg breakages by disputing females and smothering of late-hatched chicks by older nestlings.[556]

All females in the group incubate the eggs. Incubation only begins once the last egg is laid meaning that the clutch hatches synchronously about 14–15 days later. All group members brood and feed the chicks. The nestling period is 14–19 days with larger groups fledging their young more rapidly. Fledglings are unable to fly for a further 14 days, and continue to be fed for up to 8 weeks as group members continue to compete for social prestige by bringing food to the lucky recipients. Mortality is high in juveniles with up to 62% of birds dying within their first year.[557] In good conditions, Arabian Babblers are multi-brooded producing two or three broods in a year in Saudi Arabia.[558] Conversely, breeding activity is significantly reduced during drought.

Young birds achieve sexual maturity at two years of age but because of the complex cooperative breeding system, most do not mate until several years later, if at all. Around 50% of males disperse by invading an adjacent territory. Generally it is the most dominant son in the group that leads the invasion, taking his younger male siblings with him to increase his chances of ousting the incumbent dominant male. Interestingly the second ranked male usually stays behind in his parents' territory, where he will remain for his entire life until ultimately inheriting the throne and establishing his own breeding group. Most females disperse to join other groups at 2–4 years of age, typically in a small party led by the dominant daughter with her younger female siblings and/or her widowed mother. About half of the dispersing females settle into a neighboring territory while the rest join groups several territories away.[559] Ringing studies reveal that these truly amazing birds can live for at least 15 years in the wild.[560]

These fascinating studies have all focused on the breeding biology of the Arabian Babbler nesting in the northern edge of its range. Few observations have been made of the social behavior of babblers within Saudi Arabia, though there is one published report of cooperative breeding from Jabal Sawda', the highest peak in the Kingdom.[561] Likewise, recent digital video recordings show around 12 birds breeding cooperatively at a nest in al-Makhwah.[562] No doubt it would be extremely interesting to study the social behavior of this incredible bird within its Saudi Arabian range to document any local variation in its truly astonishing social behavior.

CONSERVATION STATUS

The global population of Arabian Babblers is tentatively estimated at about 150,000 annual breeding groups. Around half of the global population nests in Saudi Arabia (*see* Table 1). It can be locally common across a range of habitat types. The IUCN lists the Arabian Babbler as least concern due to the healthy population size, which is spread over a very large range. Population size might fluctuate somewhat in response to rainfall with drought causing an increase in juvenile mortality. Nonetheless, the global population is listed as "increasing" as agricultural expansion and irrigation creates new areas of suitable habitat.[563] Arabian Babblers nest in good numbers in several protected areas across western and central Saudi Arabia.

TRISTRAM'S STARLING (*ONYCHOGNATHUS TRISTRAMII*)

Tristram's Starling is the only Arabian endemic species that regularly nests within urban habitats. However, despite being a common bird of towns and villages there are surprisingly few reports of the behavior of this conspicuous and confiding bird, and no detailed studies of its behavior in natural landscapes. This is a shame because the few casual observations that have been published about Tristram's Starling indicate that this is a fascinating bird with remarkably innovative and flexible behavior. Indeed, it is this very flexibility that has enabled Tristram's Starlings to colonize urban landscapes.

TRISTRAM'S STARLING: NEAR-ENDEMIC TO THE ARABIAN PENINSULA.

Tristram's Starling belongs to the Sturnidae family, which is known simply as the starlings. The genus that includes Tristram's Starling (*Onychognathus*) contains 11 species. All other members of this genus occur across much of Africa as well as Socotra. Tristram's Starling occurs primarily in western Saudi Arabia, Yemen and southwestern Oman with small additional populations occurring patchily in the area between the southern Sinai and western Jordan.

HABITAT

In Saudi Arabia, Tristram's Starling occurs throughout the western highlands from Jordan to Yemen. It can be found from the highest peak in the Kingdom (3,000 meters) down to sea level. It prefers desolate rocky areas, nesting in crevices in high cliffs, gullies, ravines and rocky outcrops. It avoids the more arid areas to the east of the highlands. This bird has begun to exploit human modified landscapes, and thus can often be found near houses and camps, which has allowed its distribution and abundance to increase into Palestine.[564]

The highland habitat of Tristram's Starlings means that they encounter hot arid conditions in summer and rather cold conditions in winter. Physiological comparisons with Common Starling show that Tristram's Starling is much

TRISTRAM'S STARLINGS OCCUR THROUGHOUT THE HIJAZ AND 'ASIR MOUNTAINS, FROM SPARSE ROCKY HABITAT TO DENSE JUNIPER FOREST.

TRISTRAM'S STARLINGS APPEAR TO FORM LONG TERM MONOGAMOUS PAIRS THAT LAST FOR MANY YEARS.

better adapted to cope with such a wide temperature range. At high temperatures Tristram's Starlings maintain a lower body temperature, shed more body heat and lose significantly less water reserves than Common Starlings. Conversely, at low temperatures Tristram's Starlings require about 25% less oxygen to maintain body temperature, indicative of an improved ability to cope with cold conditions.[565] These adaptations have enabled Tristram's Starling to exploit mountainous habitats as year-round residents. There may be some local nomadic movements or altitudinal migration as indicated by the formation of large winter flocks in certain areas within the 'Asir Highlands in some years.[566]

FORAGING ECOLOGY

Tristram's Starlings forage in pairs and small groups, with larger foraging flocks of usually less than 100 birds forming during the non-breeding season (although around 500 birds were once recorded in a winter foraging flock in the Dhofar region of western Oman).[567] Birds in large foraging flocks generally enjoy lower predation pressure and perhaps enhanced foraging success compared to individuals feeding in smaller groups.[568] Roosts of several hundred or occasionally up to 2,000 Tristram's Starlings can form in the evenings.[569]

Tristram's Starling forages in bushes and trees or on the ground for a variety of fruits and invertebrates. It has been recorded eating an array of native fruits, including figs, berries, juniper, wild olive, Toothbrush Tree, Ziziphus, Rosehips, and dates. Further, it also eats a range of introduced plants, including Prickly Pear, Australian Saltbush, Figworts and grapes, along with the seeds of ripening sorghum. Insects recorded in the diet include beetles, grasshoppers, flies, butterflies, bees and ticks. Further, Tristram's Starlings drink regularly from freshwater pools.[570]

Tristram's Starlings often perch on the bodies of Nubian Ibex, camels and donkeys to carefully remove ticks from their hides.

Apart from its typical diet of various fruits and insects Tristram's Starling has also been reported using rather innovative methods of obtaining additional food items from the environment. For instance, it sometimes opens the shells of snails by smashing them against a stone anvil, particularly in areas containing considerable populations of land snails (such as eastern Yemen and southwestern Oman)[571] and could potentially employ the same methods in wetter areas of its Saudi Arabian range.

Interestingly, Tristram's Starling often perches on the bodies of Nubian Ibex, camels, donkeys, and perhaps other large mammals to carefully remove ticks from their hides. Indeed, in some areas of their range, birds have established regular

Males court females with gifts (such as insects and small twigs) and visual displays where the male vibrates his wings close to his body, making the chestnut patches in the wings appear as a shimmering blur.

grooming sites where ibex and camels visit for the specific purpose of having the starlings pluck the ticks from their bodies. When an ibex approaches a grooming site it signals to the birds that it is ready to be groomed by assuming a specific posture with its neck elongated. The starlings in turn make a noisy cacophony and hop up and down on the branches of nearby trees to signal that they are willing to groom the ibex. The starlings then land on the mammal and begin to remove ectoparasites from around its head and neck.[572] Both species mutually benefit from establishing these cleaning stations: the mammal has its ticks and mites removed while the bird obtains an extra source of nutrition in an essentially predator-free environment. These sorts of mutual relationships between birds and mammals are quite rare in nature.

In recent decades Tristram's Starlings have become increasingly adept at foraging around human sites. They are fond of food scraps around campsites and picnic areas and have been recorded taking cooked rice, bread and dog biscuits in towns and villages, as well as scavenging around rubbish dumps. These food sources are so abundant that birds breeding outside urban areas sometimes make long daily journeys in order to forage in town.[573]

BREEDING BIOLOGY

Tristram's Starlings appear to be monogamous with pair bonds that may last for several years (as has been well-demonstrated in several other starlings, including the closely related Red-winged Starling *O. morio*). Accordingly, pairs are often distinguishable all year round, even when foraging within their larger winter flocks. As the breeding season approaches, males begin courting females with gifts (such as insects and small twigs) and visual displays where the male vibrates his wings close to his body, making the chestnut patches in the wings appear as a shimmering blur.[574] While colored patches in the primary wing feathers are frequently found in the starling family, the significance of this "flash coloration" in mate choice remains unclear. Pairs eventually break away from the winter foraging flocks to establish individual nest territories.

Tristram's Starlings usually nest on cliffs, either solitarily or in loose colonies. They build their nests 5–20 meters above the surrounding ground level in a crevice or cave amongst rocks or on a ledge below an overhang. They occasionally build their nests in suitable holes in unoccupied buildings in urban environments and have even been recorded nesting on a lamppost in the 'Asir.

A MALE TRISTRAM'S STARLING FLASHES ITS CHESTNUT WING PATCHES TO IMPRESS THE FEMALE DURING THE BREEDING SEASON.

Both males and females contribute to building the nest, which is a ragged pad of grasses, twigs and leaves, lined with finer grasses and other soft material such as straw, cloth, hair, feathers and paper.[575] In urban environments, nests are often built using twigs from introduced tamarisk bushes.

Because nests hole are difficult to inspect, little is recorded about the nesting biology of Tristram's Starling in Saudi Arabia. A few nests were studied briefly in an urban environment in the far north of its range. Assuming those data are representative, most clutches contain 3–4 sky blue eggs with scattered brown spots concentrated at the thicker end. The female alone incubates the eggs for 15–17 days while the male guards the nest. Both parents feed the young during the 28–31 day nestling period and for a week or so after fledging. The fledglings then form juvenile flocks around two weeks after they leave the nest. The pair sometimes attempts to raise a second brood, typically reusing the same nest. Urban nests produce an average of 1·3–2·3 fledged young per pair per nest attempt;[576] likewise, no more than three fledged starlings have been recorded with adult birds in Saudi Arabia.[577]

The fact that such exceptional behavior has been recorded despite so few nests being studied suggests that a comprehensive study of Tristram's Starling would uncover a wide range of extremely interesting behavior.

Although few nests of Tristram's Starling have ever been studied in any detail, some very interesting observations have nonetheless been reported.

TRISTRAM'S STARLINGS ARE ADAPTABLE BIRDS. THEY HAVE BECOME ADEPT AT FORAGING IN HUMAN SITES AND HAVE BEEN RECORDED USING STONES TO SMASH OPEN SNAIL SHELLS.

For instance, at one of the nests in the urban population study mentioned above, one of the breeding males disappeared from the study site (presumably it died) while it still had chicks in the nest. Shortly after, a second male arrived at the nest and proceeded to kill the nestlings. This second male then took over the nest site and commenced breeding with the female.[578] Such infanticide has been reported in only a few species of mammals (including bears, lions, and some primates) and is very uncommon in birds.[579] The fact that such exceptional behavior has been recorded despite so few nests being studied suggests that a comprehensive study of Tristram's Starling would uncover a wide range of extremely interesting behavior.

Tristram's Starlings defend their nest tenaciously. Indeed, there is even a record of an adult charging out from a nest hole to accost a passing Barbary Peregrine Falcon (*Falco peregrinus pelegrinoides*) – a bird that can weigh up to 10 or 12 times heavier than a starling! The relatively tiny starling actually grabbed onto the falcon for two seconds while squawking loudly,[580] no doubt giving the falcon a fright and a bruised ego.

The colored and mottled eggs of Tristram's Starling are somewhat surprising. Most cavity nesters lay pearly white eggs. Colorful, patterned eggs that vary between individual females in a population are often an adaptive response to brood parasitism by cuckoos (because females with individually recognizable eggs have a greater chance of identifying if a cuckoo has laid a foreign egg in her nest).[581] However, none of the cuckoo species that occur in Saudi Arabia parasitize the nests of other starling species anywhere in their range, so they are unlikely to regularly parasitize the nests of Tristram's Starling either. An alternative explanation for the colorful eggs of Tristram's Starlings is that the mottled patterns act as a defense not against cuckoos but against other Tristram's Starling females that might surreptitiously dump their eggs into another female's nest.[582] Such intraspecific brood parasitism is well documented in the Common Starling and several other starling species and could conceivably occur in Tristram's Starling nests, particularly among neighboring nests in loose colonies on cliff faces.

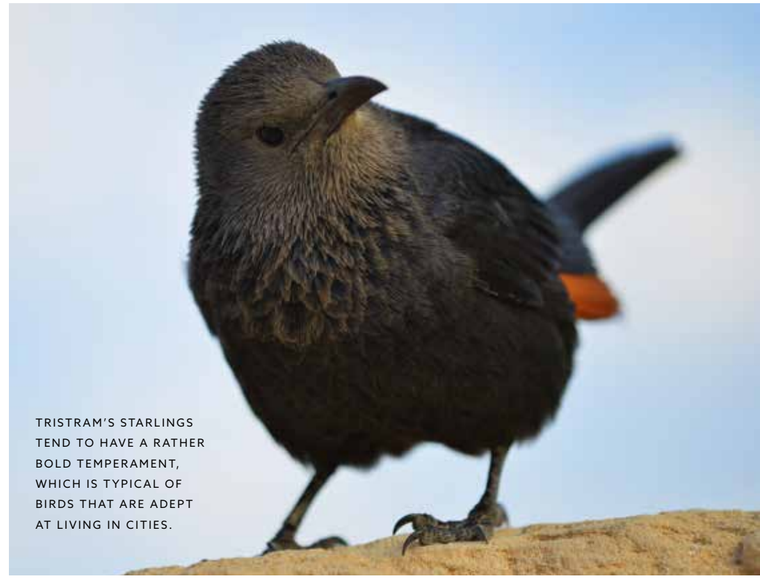
The highly modified landscape of an urban environment represents a formidable challenge for birds. Nevertheless, a few species are able to survive and even thrive in the novel environment created by cities and towns. Large-scale reviews have identified traits that urban-nesting species tend to have in common, several of which are found in Tristram's Starlings. First, as is the case for a disproportionately high number of urban-nesting birds, Tristram's Starling nests in rock cavities.[583] This is because cavity-nesting species like Tristram's Starling can often find an abundance of suitable crevices in human made structures, such as deserted buildings or infrastructure (whereas the mature native plants needed for most bush- and tree-nesting species are largely absent from urban landscapes).

Second, Tristram's Starlings exhibit considerable behavioral flexibility and innovation, which is another trait often found in species that succeed in urban environments.[584] As mentioned, some individuals have developed the ability to crack open snail shells using anvils, while others forage for ticks on the backs of ibex and camels; further, some individuals have even been flexible enough to build their nest on the top of a streetlight; in addition, urban-nesting starlings use novel materials to construct their nest, including tamarisk (which is a common tree planted in urban landscapes), and to line their nest, including products found in urban landscapes, such as cloth and paper.

Third, Tristram's Starlings have a somewhat omnivorous diet, consuming a wide variety of fruits and terrestrial insects; accordingly, a high proportion of urban-nesting species are either omnivores or seedeaters.[585] As listed above, Tristram's Starlings show considerable behavioral flexibility in their diet and now consume a broad selection of exotic plant species that are common within and around urban landscapes.

Fourth, Tristram's Starlings tend to be rather bold – at least the individuals that live in towns. Individual birds that have a "bold temperament" tend to be more successful in cities as they are able to tolerate frequent disturbance by people and vehicles.[586] One fascinating study of 44 common urban birds has revealed that species that have recently colonized urban environments are less tame and will fly significantly further when disturbed by a human, whereas species that have colonized urban environments many decades ago do not fly as far away when disturbed.[587] This suggests that urban birds can become genetically adapted to life in the city. Tristram's Starlings living in urban environments are certainly bold and allow people to come much closer to them than any other endemic species in Arabia, and they are likely to become increasingly bold as time passes. Further, birds that live in cities tend to show increased levels of territorial aggression than do their rural counterparts.[588]

Interestingly, individual birds that nest in urban settings tend to be worse off than their counterparts



TRISTRAM'S STARLINGS TEND TO HAVE A RATHER BOLD TEMPERAMENT, WHICH IS TYPICAL OF BIRDS THAT ARE ADEPT AT LIVING IN CITIES.

nesting in natural settings. Birds that nest in cities and towns usually lay their eggs earlier in the season; however, they have smaller clutches, produce chicks with lower body mass, and produce fewer fledglings per nest attempt. This is because the abundance of human-provided food in urban areas allows adult birds to maintain significantly better body weight throughout winter, leading to earlier laying dates. However, the chicks receive less nutritional benefit from the unnatural food sources found in urban landscapes. As a result, the chicks suffer reduced growth and impaired immunity during critical developmental phases, resulting in lower productivity per nesting attempt.[589] Studies need to be conducted to determine whether this is affecting reproductive success in Tristram's Starlings.

Tristram's Starlings exhibit four traits that are typical of urban-nesting species: they nest in cavities, they are omnivorous, they show remarkable behavioral flexibility, and they have a bold temperament.

CONSERVATION STATUS

Around 100,000 pairs of Tristram's Starling are estimated to exist, about 35% of which nest in Saudi Arabia (*see* Table 1). It is locally common or abundant in suitable habitat and widespread in both populated and unpopulated regions. The IUCN lists the species as least concern on account of the healthy population size and very large range and stable due to the absence of evidence for any declines or substantial threats. Indeed, the species is increasingly occupying human-modified environments and has colonized urban areas.[590] Further, it inhabits several protected areas in Saudi Arabia.

ARABIAN SPOTTED EAGLE-OWL: PROBABLY ENDEMIC TO THE ARABIAN PENINSULA

(ARABIAN) SPOTTED EAGLE-OWL (*BUBO AFRICANUS MILESI*)

The taxonomic status of the Spotted Eagle-owl in Arabia is unclear. Historically, the range of the Spotted Eagle-owl (*Bubo africanus*) was thought to include most of sub-Saharan Africa as well as southern and western Arabia. However, scientists have recently concluded that there are in fact *two* species of Spotted Eagle-owl in Africa alone – one in the north and one in the south. The two species have subtle plumage differences and moreover do not interbreed in areas where they overlap.[591] Thus, the northern population is now regarded as the Greyish Eagle-owl (*Bubo cinerascens*), while the southern populations is still called the Spotted Eagle-owl (*B. africanus*).

Genetic studies are needed to determine whether the Arabian Spotted Eagle-owl is indeed a distinct species and therefore an Arabian endemic.

Splitting the African population into two distinct species means that what we now call the Spotted Eagle-owl occurs in two very disparate areas separated by around 3,000 kilometers: one population exists in southern Africa while the other exists in Arabia with a similar but different lies in between them. This rather unlikely situation strongly suggests that the Arabian population of Spotted Eagle-owl is itself a separate species. That is, if the Spotted Eagle-owl in southern Africa is too genetically distinct to interbreed with Greyish Eagle-owls immediately to the north, then it is almost certainly even more genetically distinct from eagle-owls even further north and across the Red Sea in Arabia.

Arabian Spotted Eagle-owls will perch motionless on a branch before pouncing on their unsuspecting victims from above. They have also been observed hawking for aerial insects from streetlights in the 'Asir.

There are other reasons for suspecting that the Arabian population of the Spotted Eagle-owl is a separate species from the African population of Spotted Eagle-owls: it is smaller and more tawny colored and may also have different vocalizations.[592] In the absence of genetic data, a cautious approach is usually taken and the two populations of Spotted Eagle-owl are generally regarded as subspecies: the African Spotted Eagle-owl (*Bubo africanus africanus*) and the Arabian Spotted Eagle-owl (*Bubo africanus milesi*). Genetic studies are needed to objectively determine whether the Arabian Spotted Eagle-owl is a distinct species or a distinct subspecies.

HABITAT

In Saudi Arabia, the Arabian Spotted Eagle-owl is found in the southwest from Jiddah south to Yemen. It has been recorded from near sea level up to 2,800 meters (though it is usually found below 2,000 meters). It prefers well-wooded wadis within the foothills of the 'Asir Mountains. It is also found in rugged areas containing a mixture of trees and rocky outcrops, including the drier eastern fringe of the southwest highlands. It is generally found near water and has been recorded bathing. The larger Pharaoh Eagle-owl may exclude it from apparently suitable habitat. The Arabian Spotted Eagle-owl often occurs near human habitation.[593] Indeed, one of the best places to see this nocturnal bird of prey is around street lamps at nightfall at the edge of the escarpment near Tanumah in the 'Asir Province.

FORAGING ECOLOGY

The Arabian Spotted Eagle-owl is a strictly nocturnal bird of prey. These extraordinary birds use their exquisite hearing and nocturnal vision to identify and locate prey in near total darkness. They perch almost motionless on a branch before pouncing on their unsuspecting victims from above. Alternatively, they search actively at ground level for the telltale whispers of their prey. They have also been observed hawking for aerial insects from streetlights in the 'Asir.[594] By day, the Arabian Spotted Eagle-owl roosts amongst rocks, bushes and palm trees.

The diet of the Arabian Spotted Eagle-owl is not well reported, but includes a preponderance of invertebrates, such as beetles, mantids and grasshoppers. They are also known to catch and consume birds.[595] As is the case for most owls, the female is significantly larger than the male (by about 25% in this case), which may suggest that females capture larger prey items on average than males (as has been demonstrated in other eagle-owls, e.g. Eurasian Eagle-owl *Bubo bubo*).[596]

The full diet of the Arabian Spotted Eagle-owl is likely to be similar to that of the closely related (and better-studied) African Spotted Eagle-owl, which preys opportunistically on a wide array of food items depending on local and seasonal availability, including arthropods (scorpions, spiders and beetles), small mammals (rodents, hares, hedgehogs and bats) and birds (including quite large species such as terns, doves, falcons, hornbills and even francolins). They have also been recorded eating reptiles, amphibians, snails, freshwater crabs and occasionally carrion.[597] Given the Arabian Spotted Eagle-owl's tendency to be found near water,[598] it presumably must drink regularly (as has been reported in the African Spotted Eagle-owl).[599]

THE ARABIAN SPOTTED EAGLE-OWL IS PROBABLY ENDEMIC TO ARABIA

THE ARABIAN POPULATION OF THE AFRICAN SPOTTED EAGLE-OWL OCCURS IN SOUTHWESTERN SAUDI ARABIA (SOUTH FROM JIDDAH), WESTERN YEMEN AND OMAN.

BREEDING BIOLOGY

The breeding biology of Arabian Spotted Eagle-owls has never been studied. Based on reports of several other owl species (including the African Spotted Eagle-owl) they are likely to be socially and genetically monogamous.[600] Further, pairs of Arabian Spotted Eagle-owl have been reported to occasionally duet,[601] which is usually associated with birds that develop long-term monogamous bonds.[602] Pairs have been reported calling throughout most of the year,[603] which suggests the pair is defending a year-round all-purpose territory. Calling is most frequent from March to June (i.e., at the start of the breeding season),[604] indicating that vocalizations are also important in mate choice and maintaining pair bonds.[605]

Plumage characteristics may also be important in mate choice. For instance, a study of Eurasian Eagle-owls (*Bubo bubo*) demonstrated that although males and females appear to have identical plumage, the females actually have a much brighter ultraviolet throat patch, which is invisible to human eyes. This throat patch becomes brighter (in bird's eyes) during the breeding season, indicating that it is a sexual ornament used in mate choice.[606]

Unfortunately no nest of an Arabian Spotted Eagle-owl has ever been reported. Assuming it has similar breeding behavior to the closely related African Spotted Eagle-owl, then Arabian Spotted Eagle-owls are likely to nest in an unlined scrape placed in a hollow in a cliff, rocky outcrop, earthen bank, mature tree or building, or on an old platform nest of another species, or simply directly on the ground beneath a bush or amongst dense grass. They will often re-use the same nest site across multiple years causing the site to become littered with feathers and pellets of regurgitated indigestible food remains, such as hair and bones. Indeed, some nest sites may be used for 30–40 years.[607]

The African Spotted Eagle-owl usually lays 2–4 eggs, which are incubated solely by the female. Incubation commences after the first egg is laid, resulting in asynchronous hatching and a size hierarchy within the brood. Chicks hatch after 30–32 days. The female broods the young, while the male hunts for food from within the territory. Typically the male brings decapitated prey items to the female (after consuming the highly nutritious brains himself), who then distributes the headless prey items to the chicks. The young leave the nest after 30–38 days and usually fly well by the time they are 48 days of age.[608]

Both male and female Arabian Spotted Eagle-owls have been observed feeding fledglings, which may remain with their parents for at least five weeks or possibly until fully grown,[609] before dispersing to find a mate and establish their own territories. African Spotted Eagle-owls can be double brooded if food is abundant. Spotted Eagle-owls achieve sexual maturity around one year, and are known to live for at least 10 years in the wild.[610]

CONSERVATION STATUS

Only 2,000 pairs of Arabian Spotted Eagle-owl exist, with around 40% nesting in Saudi Arabia (*see* Table 1). This population is listed by the IUCN as least concern and stable in the absence of any firm evidence to the contrary.[611] The Arabian Spotted Eagle-owl is able to exploit built up areas and suburban sites and therefore is not likely to be under threat from development; however, it is frequently killed on roads through collision with motor vehicles.[612] Significantly, if the Arabian Spotted Eagle-owl is indeed a distinct species, then its conservation status is likely to be upgraded to Vulnerable given its small population size of only 2,000 pairs.

If the Arabian Spotted Eagle-owl is indeed a distinct species, then its conservation status is likely to be 'vulnerable' given that only 2,000 pairs exist.

CONCLUSION

This analysis of Arabian endemic and near endemic species has revealed two important conclusions: (i) the endemic birds of the Arabian Peninsula are remarkable creatures leading remarkable lives; and (ii) the endemic birds of the Arabian Peninsula are desperately understudied. Only two species (Socotra Cormorant and Arabian Babbler) have been the focus of any detailed academic research (and almost all of that research was conducted outside of Saudi Arabia). There have been preciously few reports or even casual observations of the breeding biology or foraging ecology of any of the other species. For example, less than six nests have ever been reported anywhere in Arabia for 16 of the 20 species discussed. Indeed, for at least three species (Arabian Partridge, Arabian Scops-owl and Buff-breasted Wheatear) not one nest has ever been reported. Not one. For anyone interested in studying birds, the Arabian endemic species surely represent an ornithological goldmine just waiting to be uncovered, celebrated and admired.

This chapter has highlighted the numerous gaps in our understanding of Arabia's enigmatic endemic birds in the hope that it will inspire researchers to study the hidden secrets of the extraordinary lives of Arabian birds. So let this be a call to arms. Let's fill these gaps so that we can better understand and better protect our precious endemic birds.

Who knows what extraordinary behaviors the Arabian endemic species exhibit, what remarkable adaptations they possess for overcoming the extreme climates of Saudi Arabia, what conservation threats they currently face, or indeed whether these populations will remain viable into the foreseeable future?

COMMON STONECHAT

APPENDIX 1: NON-BIRD SPECIES NAMES USED IN THE BOOK

COMMON NAME	SCIENTIFIC NAME
Acacia	*Acacia spp.*
Alfalfa	*Medicago sativa*
Aloe	*Aloe vera*
Anchovies	*Encrasicholina spp.*
Anisotes	*Anisotes trisulcus*
Arabian Boxthorn	*Lycium shawii*
Arabian Horned Viper	*Cerastes gasperettii*
Arabian Leopard	*Panthera pardus nimr*
Arabian Red Fox	*Vulpes vulpes arabica*
Australian Saltbush	*Atriplex semibaccata*
Arabian Spiny Mouse	*Acomys dimidiatus*
Arabian Stocks	*Corchorus depressus*
Black Mangrove	*Avicennia marina*
Blue-stripe Sardine	*Herklostychthyes quadrimaculatus*
Calotropis	*Calotropis procera*
Cape Hare	*Lepus capensis*
Capparis	*Capparis spp*
Cattail	*Typha spp. (probably T. latifolia)*
Common Reed	*Phragmites australis*
Conch	*Lambis truncata*
Cordia	*Cordia abyssinica*
Date Palm	*Phoenix dactylifera*
Desert Gourd	*Citrullus colocynthis*
Doum Palm	*Hyphaene thebaica*
Elb	*Zizyphus spinacristi*
Eucalyptus	*Eucalyptus spp.*
Figs	*Ficus nitida, F. vasta*
Figworts	*Myoporum spp.*
Fruit Flies	*Drosophila spp.*
Ghaf	*Prosopis cineraria*
Golden Jackals	*Canis aureus*
Golden Spiny Mouse	*Acomys russatus*
Hamadryas Baboon	*Papio hamadryas*
Hanging Tree Lichen	*Usnea spp.*
Honey Badger	*Mellivora capensis*
Juncus	*Juncus spp.*
Locusts	*Schistocerca gregaria*
Maerua	*Maerua crassifolia*
Moringa	*Moringa peregrina*
Myrrhs	*Commiphora spp.*
Nubian Ibex	*Capra nubiana*
Nuxia	*Nuxia oppositifolia or N. congesta*
Oleander	*Nerium oleander*
Olive	*Olea chrysophylla*
Pandanus	*Pandanus spp.*
Pink-eared Emperor	*Lethrinus lentjan*
Prickly Pear	*Opuntia spp.*
Rock Hyrax	*Procavia capensis*
Rosehip	*Rosa abyssinica*
Rumex	*Rumex spp.*
Sailfin Flying Fish	*Parexocoetus mento*
Salvia	*Salvia spp.*
Sand Monitor	*Varanus griseus*
Sardines	*Sardinella spp.*
Scads	*Selar crumenophthalmus, Atule mate*
Shrubby Sea-blite	*Suaeda fruticosa*
Silverside	*Atherino morphuslacunosus*
Spotted Half-beak	*Hemiramphus far*
Stereospermum	*Stereospermum spp.*
Streaked Rabbit-fish	*Siganus javus*
Striped Hyaena	*Hyaena hyaena*
Sugar Sorghum	*Sorgum bicolor*
Tamarisk	*Tamarix spp.*
Toothbrush Tree	*Salvadora persica*
Umbrella Thorn	*Acacia tortilis*
White Gul Mohur	*Delonix elata*
Ziziphus	*Ziziphus spina-christi*
Zobra	*Dobera glabra*

APPENDIX 2: CHECKLIST OF THE BIRDS OF SAUDI ARABIA

* Vagrant to Saudi Arabia (recorded on less than 10 occasions)

NO	ORDER	FAMILY	SCIENTIFIC NAME	COMMON NAME	ARABIC NAME
1	Struthioniformes	Ostriches (Struthionidae)	*Struthio camelus*	Common Ostrich	النعامة
2	Galliformes	Guineafowl (Numididae)	*Numida meleagris*	Helmeted Guineafowl	دجاجة حبشية
3	Galliformes	Pheasants, Partridges, Turkeys, Grouse (Phasianidae)	*Coturnix coturnix*	Common Quail	سماني شائعة
4	Galliformes	Pheasants, Partridges, Turkeys, Grouse (Phasianidae)	*Coturnix delegorguei*	Harlequin Quail	سماني مهرجة (السمان الضاحك)
5	Galliformes	Pheasants, Partridges, Turkeys, Grouse (Phasianidae)	*Alectoris chukar*	Chukar	حجل شائع
6	Galliformes	Pheasants, Partridges, Turkeys, Grouse (Phasianidae)	*Alectoris philbyi*	Philby's Partridge	قهبية (حجل فيلبي)
7	Galliformes	Pheasants, Partridges, Turkeys, Grouse (Phasianidae)	*Alectoris melanocephala*	Arabian Partridge	حجل عربي
8	Galliformes	Pheasants, Partridges, Turkeys, Grouse (Phasianidae)	*Ammoperdix griseogularis*	See-see partridge	طيهوج (حجل سي سي)
9	Galliformes	Pheasants, Partridges, Turkeys, Grouse (Phasianidae)	*Ammoperdix heyi*	Sand Partridge	حجل رملي
10	Galliformes	Pheasants, Partridges, Turkeys, Grouse (Phasianidae)	*Francolinus pondicerianus*	Grey Francolin	دراج أرمد
11	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Dendrocygna bicolor*	Fulvous Whistling-duck*	صافرة بنية (البط المصفر)
12	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Dendrocygna javanica*	Lesser Whistling-duck*	صافرة صغيرة
13	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Oxyura leucocephala*	White-headed Duck*	بطة رخماء (بط أبيض الرأس)
14	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Cygnus columbianus*	Tundra Swan*	تم بويكي
15	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Anser anser*	Greylag Goose	إوزة برداء
16	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Anser albifrons*	Greater White-fronted Goose	إوزة غراء كبيرة
17	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Mergellus albellus*	Smew*	مقشوشة بيضاء (بلقشة بيضاء)
18	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Mergus serrator*	Red-breasted Merganser*	مقشوشة حمراء صدر
19	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Alopochen aegyptiaca*	Egyptian Goose*	إوزة مصرية
20	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Tadorna tadorna*	Common Shelduck	شهرمانة
21	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Tadorna ferruginea*	Ruddy Shelduck	شهرمانة حمراء (بط أبو فروة)
22	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Nettapus coromandelianus*	Cotton Pygmy-goose*	إوزة ضئيلة قطنية (حذف قطني)
23	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Marmaronetta angustirostris*	Marbled Teal*	حذفة رخامية (حذف مخطط)
24	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Netta rufina*	Red-crested Pochard	بطة حمراء قنة (الونس)
25	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Aythya ferina*	Common Pochard	بطة حمراء رأس (حمراوي)
26	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Aythya nyroca*	Ferruginous Duck	بطة كميت (حمراوي أبيض العين)
27	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Aythya fuligula*	Tufted Duck	بطة قنبراء (أبو خصلة)
28	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Spatula querquedula*	Garganey	حذفة صيفية
29	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Spatula clypeata*	Northern Shoveler	مجرفي منقار (أبو مجرف)
30	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Mareca strepera*	Gadwall	سمارية (بط سماري)
31	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Mareca penelope*	Eurasian Wigeon	صواية
32	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Anas platyrhynchos*	Mallard	خضاري
33	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Anas acuta*	Northern Pintail	بلبول شمالي
34	Anseriformes	Ducks, Geese, Swans (Anatidae)	*Anas crecca*	Common Teal	حذفة شتوية
35	Podicipediformes	Grebes (Podicipedidae)	*Tachybaptus ruficollis*	Little Grebe	غطاس صغير
36	Podicipediformes	Grebes (Podicipedidae)	*Podiceps grisegena*	Red-necked Grebe*	غطاس أحمر الرقبة
37	Podicipediformes	Grebes (Podicipedidae)	*Podiceps cristatus*	Great Crested Grebe	غطاس قنبرى (غطاس متوج كبير)
38	Podicipediformes	Grebes (Podicipedidae)	*Podiceps nigricollis*	Black-necked Grebe	غطاس أدرع (غطاس أسود الرقبة)
39	Phoenicopteriformes	Flamingos (Phoenicopteridae)	*Phoenicopterus roseus*	Greater Flamingo	النحام الكبير
40	Phoenicopteriformes	Flamingos (Phoenicopteridae)	*Phoeniconaias minor*	Lesser Flamingo	النحام الصغير
41	Phaethontiformes	Tropicbirds (Phaethontidae)	*Phaethon aethereus*	Red-billed Tropicbird	استوائي أحمر منقار
42	Columbiformes	Pigeons, Doves (Columbidae)	*Columba livia*	Rock Dove	يمامة برية (حمام جبلي)
43	Columbiformes	Pigeons, Doves (Columbidae)	*Columba palumbus*	Common Woodpigeon	ورشان (حمام الغابات)

44	Columbiformes	Pigeons, Doves (Columbidae)	*Columba arquatrix*	African Olive-pigeon	حمامة زيتونية أفريقية
45	Columbiformes	Pigeons, Doves (Columbidae)	*Streptopelia turtur*	European Turtle-dove	القمري الأوروبي
46	Columbiformes	Pigeons, Doves (Columbidae)	*Streptopelia lugens*	Dusky Turtle-dove	أنن (قمري نوام)
47	Columbiformes	Pigeons, Doves (Columbidae)	*Streptopelia orientalis*	Oriental Turtle-dove*	قمري أصهب (قمري شرقي)
48	Columbiformes	Pigeons, Doves (Columbidae)	*Streptopelia decaocto*	Eurasian Collared-dove	فاختة أوراسية (يمام مطوق)
49	Columbiformes	Pigeons, Doves (Columbidae)	*Streptopelia roseogrisea*	African Collared-dove	فاختة أفريقية (يمام مطوق أفريقي)
50	Columbiformes	Pigeons, Doves (Columbidae)	*Streptopelia semitorquata*	Red-eyed Dove	ساق حر (يمام أحمر العين)
51	Columbiformes	Pigeons, Doves (Columbidae)	*Spilopelia senegalensis*	Laughing Dove	دبسي (يمام النخيل)
52	Columbiformes	Pigeons, Doves (Columbidae)	*Oena capensis*	Namaqua Dove	حمحم (يمام طويل الذيل)
53	Columbiformes	Pigeons, Doves (Columbidae)	*Treron waalia*	Bruce's Green-pigeon	رهطى (الحمامة الخضراء)
54	Pteroclifformes	Sandgrouse (Pteroclidae)	*Pterocles orientalis*	Black-bellied Sandgrouse	جونية (قطا أسود البطن)
55	Pteroclifformes	Sandgrouse (Pteroclidae)	*Pterocles exustus*	Chestnut-bellied Sandgrouse	غطاطة (قطا كستنائي البطن)
56	Pteroclifformes	Sandgrouse (Pteroclidae)	*Pterocles senegallus*	Spotted Sandgrouse	كدرية ذنوب (قطا مرقط)
57	Pteroclifformes	Sandgrouse (Pteroclidae)	*Pterocles coronatus*	Crowned Sandgrouse	كدرية شائعة (قطا متوج)
58	Pteroclifformes	Sandgrouse (Pteroclidae)	*Pterocles alchata*	Pin-tailed Sandgrouse	قطاة نبطاء
59	Pteroclifformes	Sandgrouse (Pteroclidae)	*Pterocles lichtensteinii*	Lichtenstein's Sandgrouse	كدرية حجازية (قطا مخطط)
60	Caprimulgiformes	Nightjars (Caprimulgidae)	*Caprimulgus europaeus*	European Nightjar	سبد أوروبي
61	Caprimulgiformes	Nightjars (Caprimulgidae)	*Caprimulgus aegyptius*	Egyptian Nightjar	سبد مصري
62	Caprimulgiformes	Nightjars (Caprimulgidae)	*Caprimulgus nubicus*	Nubian Nightjar	سبد نوبي
63	Caprimulgiformes	Nightjars (Caprimulgidae)	*Caprimulgus poliocephalus*	Montane Nightjar	سبد أرمد الرأس (سبد الجبال)
64	Caprimulgiformes	Nightjars (Caprimulgidae)	*Caprimulgus inornatus*	Plain Nightjar	سبد بهيم (سبد السهول)
65	Caprimulgiformes	Swifts (Apodidae)	*Cypsiurus parvus*	African Palm-swift	سمامة نخيل أفريقية
66	Caprimulgiformes	Swifts (Apodidae)	*Tachymarptis melba*	Alpine Swift	سمامة ألبية (سمامة الصرود)
67	Caprimulgiformes	Swifts (Apodidae)	*Apus caffer*	White-rumped Swift*	سمامة عجزاء (سمامة بيضاء العجز)
68	Caprimulgiformes	Swifts (Apodidae)	*Apus affinis*	Little Swift	سمامة صغيرة
69	Caprimulgiformes	Swifts (Apodidae)	*Apus pallidus*	Pallid Swift	سمامة فاتحة
70	Caprimulgiformes	Swifts (Apodidae)	*Apus apus*	Common Swift	سمامة شائعة
71	Cuculiformes	Cuckoos (Cuculidae)	*Centropus superciliosus*	White-browed Coucal	صليقاء (وقواق أبيض الحاجب)
72	Cuculiformes	Cuckoos (Cuculidae)	*Clamator jacobinus*	Jacobin Cuckoo	وقواق أبقع (الوقواق الرزين)
73	Cuculiformes	Cuckoos (Cuculidae)	*Clamator glandarius*	Great Spotted Cuckoo	وقواق أرقط كبير
74	Cuculiformes	Cuckoos (Cuculidae)	*Chrysococcyx klaas*	Klaas's Cuckoo	وقواق اكلاسي
75	Cuculiformes	Cuckoos (Cuculidae)	*Chrysococcyx caprius*	Diederik Cuckoo	وقواق أخضر ظهر
76	Cuculiformes	Cuckoos (Cuculidae)	*Cuculus canorus*	Common Cuckoo	وقواق شائع
77	Gruiformes	Rails, Gallinules, Coots (Rallidae)	*Rallus aquaticus*	Western Water Rail	مرعة الماء
78	Gruiformes	Rails, Gallinules, Coots (Rallidae)	*Crex crex*	Corncrake	مرعة الحقل
79	Gruiformes	Rails, Gallinules, Coots (Rallidae)	*Porzana porzana*	Spotted Crake	مرعة رقطاء (سلوى)
80	Gruiformes	Rails, Gallinules, Coots (Rallidae)	*Zapornia parva*	Little Crake	مرعة صغيرة
81	Gruiformes	Rails, Gallinules, Coots (Rallidae)	*Zapornia pusilla*	Baillon's Crake	مرعة بيلونية
82	Gruiformes	Rails, Gallinules, Coots (Rallidae)	*Amaurornis phoenicurus*	White-breasted Waterhen*	دجاجة ماء صدراء
83	Gruiformes	Rails, Gallinules, Coots (Rallidae)	*Porphyrio porphyrio*	Purple Swamphen	فرفر أرجواني (سحنون)
84	Gruiformes	Rails, Gallinules, Coots (Rallidae)	*Gallinula chloropus*	Common Moorhen	فرفر شائع (دجاجة الماء)
85	Gruiformes	Rails, Gallinules, Coots (Rallidae)	*Fulica cristata*	Red-knobbed Coot*	غراء محمرة منقار
86	Gruiformes	Rails, Gallinules, Coots (Rallidae)	*Fulica atra*	Common Coot	
87	Gruiformes	Cranes (Gruidae)	*Anthropoides virgo*	Demoiselle Crane	غراء أوراسية
88	Gruiformes	Cranes (Gruidae)	*Grus grus*	Common Crane	الرهو
89	Otidiformes	Bustards (Otididae)	*Tetrax tetrax*	Little Bustard*	كركي شائع
90	Otidiformes	Bustards (Otididae)	*Otis tarda*	Great Bustard*	حبارى صغيرة
91	Otidiformes	Bustards (Otididae)	*Chlamydotis macqueenii*	Asian Houbara	حبارى كبيرة
92	Otidiformes	Bustards (Otididae)	*Ardeotis arabs*	Arabian Bustard	حبارى شرقية
93	Procellariiformes	Southern Storm-petrels (Oceanitidae)	*Oceanites oceanicus*	Wilson's Storm-petrel	حبارى عربية
94	Procellariiformes	Petrels, Shearwaters (Procellariidae)	*Puffinus persicus*	Persian Shearwater*	نوء ويلسوني
95	Procellariiformes	Petrels, Shearwaters (Procellariidae)	*Bulweria fallax*	Jouanin's Petrel*	جلم فارسي
96	Ciconiiformes	Storks (Ciconiidae)	*Ciconia nigra*	Black Stork	نوء جوانيني
97	Ciconiiformes	Storks (Ciconiidae)	*Ciconia abdimii*	Abdim's Stork	لقلق أسود
98	Ciconiiformes	Storks (Ciconiidae)	*Ciconia ciconia*	White Stork	لقلق عابديني
99	Pelecaniformes	Ibises, Spoonbills (Threskiornithidae)	*Platalea leucorodia*	Eurasian Spoonbill	لقلق أبيض غربي
100	Pelecaniformes	Ibises, Spoonbills (Threskiornithidae)	*Threskiornis aethiopicus*	African Sacred Ibis*	ملعقي منقار أوراسي (أبو ملعقة)
101	Pelecaniformes	Ibises, Spoonbills (Threskiornithidae)	*Geronticus eremita*	Northern Bald Ibis	أنوق مقدس أفريقي (أبو منجل الأثيوبي)
102	Pelecaniformes	Ibises, Spoonbills (Threskiornithidae)	*Plegadis falcinellus*	Glossy Ibis	أنوق أصلع شمالي (أبو منجل الأصلع)
103	Pelecaniformes	Herons (Ardeidae)	*Botaurus stellaris*	Eurasian Bittern	أنوق لماع (أبو منجل اللامع)
104	Pelecaniformes	Herons (Ardeidae)	*Ixobrychus minutus*	Common Little Bittern	واق أوراسي
105	Pelecaniformes	Herons (Ardeidae)	*Ixobrychus sinensis*	Yellow Bittern*	واق صغير
106	Pelecaniformes	Herons (Ardeidae)	*Nycticorax nycticorax*	Black-crowned Night Heron	واق أصفر
107	Pelecaniformes	Herons (Ardeidae)	*Butorides striata*	Green-backed Heron	بلشون ليل أرأس
108	Pelecaniformes	Herons (Ardeidae)	*Ardeola ralloides*	Squacco Heron	بلشون محزز (بلشون أخضر الظهر)
109	Pelecaniformes	Herons (Ardeidae)	*Bubulcus ibis*	Cattle Egret	بلشون مذهب (واق أبيض صغير)
110	Pelecaniformes	Herons (Ardeidae)	*Ardea cinerea*	Grey Heron	بلشون بقر غربي (أبوقردان)
111	Pelecaniformes	Herons (Ardeidae)	*Ardea melanocephala*	Black-headed Heron	بلشون أرمد
112	Pelecaniformes	Herons (Ardeidae)	*Ardea goliath*	Goliath Heron	بلشون أرأس
113	Pelecaniformes	Herons (Ardeidae)	*Ardea purpurea*	Purple Heron	بلشون عملاق
114	Pelecaniformes	Herons (Ardeidae)	*Ardea alba*	Great White Egret	بلشون أرجوان
115	Pelecaniformes	Herons (Ardeidae)	*Egretta garzetta*	Little Egret	بلشون كبير غربي (بلشون أبيض كبير)
116	Pelecaniformes	Herons (Ardeidae)	*Egretta gularis*	Western Reef-egret	غرنوق أبيض صغير (بلشون أبيض صغير)
117	Pelecaniformes	Hamerkop (Scopidae)	*Scopus umbretta*	Hamerkop	غرنوق صخر هندي (بلشون الصخر)
118	Pelecaniformes	Pelicans (Pelecanidae)	*Pelecanus rufescens*	Pink-backed Pelican	مطرقي منقار
119	Pelecaniformes	Pelicans (Pelecanidae)	*Pelecanus onocrotalus*	Great White Pelican	بجعة وردة ظهر
120	Suliformes	Frigatebirds (Fregatidae)	*Fregata ariel*	Lesser Frigatebird*	بجعة بيضاء
121	Suliformes	Gannets, Boobies (Sulidae)	*Sula leucogaster*	Brown Booby	فرقاط صغير
122	Suliformes	Gannets, Boobies (Sulidae)	*Sula dactylatra*	Masked Booby*	أطيش بني
123	Suliformes	Cormorants (Phalacrocoracidae)	*Phalacrocorax carbo*	Great Cormorant	أطيش مبرقع
124	Suliformes	Cormorants (Phalacrocoracidae)	*Phalacrocorax nigrogularis*	Socotra Cormorant	الغاق الكبير
125	Charadriiformes	Thick-knees (Burhinidae)	*Burhinus oedicnemus*	Eurasian Thick-knee	الغاق السوقطري
126	Charadriiformes	Thick-knees (Burhinidae)	*Burhinus senegalensis*	Senegal Thick-knee*	كروان أوراسي
127	Charadriiformes	Thick-knees (Burhinidae)	*Burhinus capensis*	Spotted Thick-knee	كروان سنغالي
128	Charadriiformes	Oystercatchers (Haematopodidae)	*Haematopus ostralegus*	Eurasian Oystercatcher	كروان أرقط
129	Charadriiformes	Avocets, Stilts (Recurvirostridae)	*Recurvirostra avosetta*	Pied Avocet	محاري أوراسي (آكل المحار)
130	Charadriiformes	Avocets, Stilts (Recurvirostridae)	*Himantopus himantopus*	Black-winged Stilt	نكات أبقع
131	Charadriiformes	Plovers (Charadriidae)	*Pluvialis squatarola*	Grey Plover	طول أجنح (أبو المغازل)
132	Charadriiformes	Plovers (Charadriidae)	*Pluvialis apricaria*	Eurasian Golden Plover	زقزاق أرمد
133	Charadriiformes	Plovers (Charadriidae)	*Pluvialis fulva*	Pacific Golden Plover	زقزاق مذهب أوراسي
134	Charadriiformes	Plovers (Charadriidae)	*Eudromias morinellus*	Eurasian Dotterel	زقزاق مذهب سيبيري
135	Charadriiformes	Plovers (Charadriidae)	*Charadrius hiaticula*	Common Ringed Plover	زقزاق أغبر
136	Charadriiformes	Plovers (Charadriidae)	*Charadrius dubius*	Little Ringed Plover	زقزاق مطوق شائع
137	Charadriiformes	Plovers (Charadriidae)	*Charadrius pecuarius*	Kittlitz's Plover*	زقزاق مطوق صغير
138	Charadriiformes	Plovers (Charadriidae)	*Charadrius alexandrinus*	Kentish Plover	زقزاق كتلتزي
139	Charadriiformes	Plovers (Charadriidae)	*Charadrius mongolus*	Lesser Sandplover	زقزاق إسكندري
140	Charadriiformes	Plovers (Charadriidae)	*Charadrius leschenaultii*	Greater Sandplover	زقزاق صغير
141	Charadriiformes	Plovers (Charadriidae)	*Charadrius asiaticus*	Caspian Plover	زقزاق كبير
142	Charadriiformes	Plovers (Charadriidae)	*Vanellus vanellus*	Northern Lapwing	زقزاق قزويني
143	Charadriiformes	Plovers (Charadriidae)	*Vanellus spinosus*	Spur-winged Lapwing	قطقاط شمالي
144	Charadriiformes	Plovers (Charadriidae)	*Vanellus indicus*	Red-wattled Lapwing	قطقاط أشوك
145	Charadriiformes	Plovers (Charadriidae)	*Vanellus gregarius*	Sociable Lapwing	قطقاط أحمر لغد
146	Charadriiformes	Plovers (Charadriidae)	*Vanellus leucurus*	White-tailed Lapwing	قطقاط تجمعي

147	Charadriiformes	Painted-snipes (Rostratulidae)	*Rostratula benghalensis*	Greater Painted-snipe	قطقاط أغوك
148	Charadriiformes	Jacanas (Jacanidae)	*Hydrophasianus chirurgus*	Pheasant-tailed Jacana*	شنقب ملون
149	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Numenius phaeopus*	Whimbrel	جاكنة ذنوب (يقنة تدرجية الذيل)
150	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Numenius arquata*	Eurasian Curlew	نهقة آجام (كروان الماء الصغير)
151	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Limosa lapponica*	Bar-tailed Godwit	نهقة أوراسية (كروان الماء)
152	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Limosa limosa*	Black-tailed Godwit	قوق موشم ذنب (بقويقة مخططة الذيل)
153	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Arenaria interpres*	Ruddy Turnstone	قوق أشعل (بقويقة سوداء الذيل)
154	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Calidris tenuirostris*	Great Knot	قنبرة الماء
155	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Calidris canutus*	Red Knot*	طيطوى كبيرة (الدريجة الكبيرة)
156	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Calidris pugnax*	Ruff	طيطوى حمراء (الدريجة الحمراء)
157	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Calidris falcinellus*	Broad-billed Sandpiper	أغثر (حجوالة)
158	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Calidris ferruginea*	Curlew Sandpiper	طيطوى شدقاء (طيطوى عريضة المنقار)
159	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Calidris temminckii*	Temminck's Stint	طيطوى نهقية (طيطوى مقوسة المنقار)
160	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Calidris subminuta*	Long-toed Stint*	طيطوى تمنكية
161	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Calidris alba*	Sanderling	طيطوى صبغاء
162	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Calidris alpina*	Dunlin	طيطوى بيضاء (مدروان)
163	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Calidris minuta*	Little Stint	طيطوى دراجة
164	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Calidris subruficollis*	Buff-breasted Sandpiper*	طيطوى صغيرة
165	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Calidris melanotos*	Pectoral Sandpiper*	طيطوى آدمة صدر (طيطوى برتقالية الصدر)
166	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Scolopax rusticola*	Eurasian Woodcock	طيطوى نبطاء
167	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Gallinago solitaria*	Solitary Snipe*	دجاجة غاب (ديك الغاب)
168	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Gallinago stenura*	Pintail Snipe*	شنقب منفرد
169	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Gallinago media*	Great Snipe	شنقب إبري ذنب
170	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Gallinago gallinago*	Common Snipe	شنقب كبير
171	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Lymnocryptes minimus*	Jack Snipe	شنقب شائع
172	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Phalaropus lobatus*	Red-necked Phalarope	شنقب صغير
173	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Phalaropus fulicarius*	Red Phalarope*	فلرب أحمر رقبة
174	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Xenus cinereus*	Terek Sandpiper	فلرب أرمد

175	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Actitis hypoleucos*	Common Sandpiper	طيطوى رملية
176	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Tringa ochropus*	Green Sandpiper	طيطوى شائعة
177	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Tringa erythropus*	Spotted Redshank	طيطوى خضراء
178	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Tringa nebularia*	Common Greenshank	حمراء ساق رقطاء
179	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Tringa totanus*	Common Redshank	خضراء ساق
180	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Tringa glareola*	Wood Sandpiper	حمراء ساق
181	Charadriiformes	Sandpipers, Snipes, Phalaropes (Scolopacidae)	*Tringa stagnatilis*	Marsh Sandpiper	طيطوى آجمية (طيطوى الغياض)
182	Charadriiformes	Buttonquails (Turnicidae)	*Turnix sylvaticus*	Common Buttonquail	طيطوى مستنقعية
183	Charadriiformes	Crab-plover (Dromadidae)	*Dromas ardeola*	Crab-plover	بتراء صغيرة (سمان الشجر الصغير)
184	Charadriiformes	Coursers, Pratincoles (Glareolidae)	*Cursorius cursor*	Cream-coloured Courser	حنكور
185	Charadriiformes	Coursers, Pratincoles (Glareolidae)	*Glareola pratincola*	Collared Pratincole	دراج شائع (كروان عسلي)
186	Charadriiformes	Coursers, Pratincoles (Glareolidae)	*Glareola nordmanni*	Black-winged Pratincole	يسر مطوق
187	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Anous stolidus*	Brown Noddy	يسر أجنح
188	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Hydrocoloeus minutus*	Little Gull*	أبله بني
189	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Rissa tridactyla*	Black-legged Kittiwake*	نورس صغير
190	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Larus genei*	Slender-billed Gull	نورس أرمل (نورس كيتيويك)
191	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Larus ridibundus*	Black-headed Gull	نورس مستدق المنقار
192	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Larus cirrocephalus*	Grey-headed Gull*	نورس أراس
193	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Larus ichthyaetus*	Pallas's Gull	نورس أرمد رأس
194	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Larus melanocephalus*	Mediterranean Gull*	نورس أراس كبير
195	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Larus hemprichii*	Sooty Gull	نورس متوسطي
196	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Larus leucophthalmus*	White-eyed Gull	نورس أسحم
197	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Larus canus*	Mew Gull	نورس غرب (نورس أبيض العين)
198	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Larus fuscus*	Lesser Black-backed Gull	نورس شائع
199	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Larus armenicus*	Armenian Gull	نورس أظهر صغير
200	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Larus michahellis*	Yellow-legged Gull*	نورس أرميني
201	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Larus cachinnans*	Caspian Gull	نورس مجبب (نورس أصفر ساق)
202	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Onychoprion fuscatus*	Sooty Tern*	نورس قزويني
203	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Onychoprion anaethetus*	Bridled Tern	خرشنة سخماء
204	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Sternula albifrons*	Little Tern	خرشنة لجماء
205	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Sternula saundersi*	Saunders's Tern	خرشنة صغيرة
206	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Gelochelidon nilotica*	Common Gull-billed Tern	خرشنة سوندرزية
207	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Hydroprogne caspia*	Caspian Tern	خرشنة نورسية منقار
208	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Chlidonias hybrida*	Whiskered Tern	خرشنة قزوينية
209	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Chlidonias leucopterus*	White-winged Tern	خرشنة سبلاء
210	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Chlidonias niger*	Black Tern	خرشنة عصماء
211	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Sterna dougallii*	Roseate Tern*	خرشنة سوداء
212	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Sterna hirundo*	Common Tern	خرشنة وردة
213	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Sterna repressa*	White-cheeked Tern	خرشنة شائعة
214	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Thalasseus bengalensis*	Lesser Crested Tern	خرشنة غشواء (خرشنة بيضاء الخد)
215	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Thalasseus sandvicensis*	Sandwich Tern	خرشنة عرفاء صغيرة
216	Charadriiformes	Gulls, Terns, Skimmers (Laridae)	*Thalasseus bergii*	Greater Crested Tern	خرشنة ساندويتشية
217	Charadriiformes	Skuas (Stercorariidae)	*Stercorarius longicaudus*	Long-tailed Jaeger*	خرشنة عرفاء كبيرة
218	Charadriiformes	Skuas (Stercorariidae)	*Stercorarius parasiticus*	Arctic Jaeger	كركر ذنوب
219	Charadriiformes	Skuas (Stercorariidae)	*Stercorarius pomarinus*	Pomarine Jaeger	كركر قطبي شمالي
220	Strigiformes	Barn-owls (Tytonidae)	*Tyto alba*	Common Barn-owl	كركر قشري منقار
221	Strigiformes	Typical Owls (Strigidae)	*Athene noctua*	Little Owl	هامة (بومة بيضاء)
222	Strigiformes	Typical Owls (Strigidae)	*Otus pamelae*	Arabian Scops-owl	صدى (بومة صغيرة)

223	Strigiformes	Typical Owls (Strigidae)	*Otus scops*	Eurasian Scops-owl	ثيج عربي (بومة الأشجار العربية)
224	Strigiformes	Typical Owls (Strigidae)	*Otus brucei*	Pallid Scops-owl	ثيج أوراسي (بومة الأشجار الأوروبية)
225	Strigiformes	Typical Owls (Strigidae)	*Asio otus*	Northern Long-eared Owl*	ثيج فاتح (بومة الأشجار المخططة)
226	Strigiformes	Typical Owls (Strigidae)	*Asio flammeus*	Short-eared Owl	بومة أذناء
227	Strigiformes	Typical Owls (Strigidae)	*Strix hadorami*	Desert Tawny Owl	بومة صمعاء
228	Strigiformes	Typical Owls (Strigidae)	*Bubo ascalaphus*	Pharaoh Eagle-owl	بومة الصحراء
229	Strigiformes	Typical Owls (Strigidae)	*Bubo africanus*	Spotted Eagle-owl	بومة صحراوية (بوم فرعوني)
230	Accipitriformes	Osprey (Pandionidae)	*Pandion haliaetus*	Osprey	بومة رقطاء عربية (بومة عقابية مرقطة)
231	Accipitriformes	Hawks, Eagles (Accipitridae)	*Elanus caeruleus*	Black-winged Kite	عقاب نسارية
232	Accipitriformes	Hawks, Eagles (Accipitridae)	*Pernis apivorus*	European Honey-buzzard	زرق شائع (الحدأة سوداء الجناح)
233	Accipitriformes	Hawks, Eagles (Accipitridae)	*Pernis ptilorhynchus*	Oriental Honey-buzzard	عقيب العسل أوروبية (حوام العسل الأوروبي)
234	Accipitriformes	Hawks, Eagles (Accipitridae)	*Gypaetus barbatus*	Bearded Vulture	عقيب العسل شرقية (حوام متوج)
235	Accipitriformes	Hawks, Eagles (Accipitridae)	*Neophron percnopterus*	Egyptian Vulture	ستل (النسر الملتحي)
236	Accipitriformes	Hawks, Eagles (Accipitridae)	*Terathopius ecaudatus*	Bateleur	رخمة
237	Accipitriformes	Hawks, Eagles (Accipitridae)	*Circaetus gallicus*	Short-toed Snake-eagle	عقاب بهلوانية (العقاب المصفق)
238	Accipitriformes	Hawks, Eagles (Accipitridae)	*Gyps rueppelli*	Ruppell's Vulture*	صرارة (عقاب الثعابين)
239	Accipitriformes	Hawks, Eagles (Accipitridae)	*Gyps fulvus*	Griffon Vulture	نسر روبلي
240	Accipitriformes	Hawks, Eagles (Accipitridae)	*Aegypius monachus*	Cinereous Vulture	نسر أوراسي (النسر الأسمر)
241	Accipitriformes	Hawks, Eagles (Accipitridae)	*Torgos tracheliotos*	Lappet-faced Vulture	نسر مسود
242	Accipitriformes	Hawks, Eagles (Accipitridae)	*Clanga pomarina*	Lesser Spotted Eagle*	نسر آذن
243	Accipitriformes	Hawks, Eagles (Accipitridae)	*Clanga clanga*	Greater Spotted Eagle	عقاب رقطاء صغرى
244	Accipitriformes	Hawks, Eagles (Accipitridae)	*Aquila rapax*	Tawny Eagle	عقاب رقطاء كبرى
245	Accipitriformes	Hawks, Eagles (Accipitridae)	*Aquila nipalensis*	Steppe Eagle	عقاب صحماء
246	Accipitriformes	Hawks, Eagles (Accipitridae)	*Aquila heliaca*	Eastern Imperial Eagle	عقاب سهبية (عقاب السهول)
247	Accipitriformes	Hawks, Eagles (Accipitridae)	*Aquila chrysaetos*	Golden Eagle	عقاب ملكية شرقية
248	Accipitriformes	Hawks, Eagles (Accipitridae)	*Aquila verreauxii*	Verreaux's Eagle	عقاب مذهبة
249	Accipitriformes	Hawks, Eagles (Accipitridae)	*Aquila fasciata*	Bonelli's Eagle	عقاب خدارية (العقاب الأسود)
250	Accipitriformes	Hawks, Eagles (Accipitridae)	*Hieraaetus pennatus*	Booted Eagle	عقاب بونلية (عقاب مخططة)
251	Accipitriformes	Hawks, Eagles (Accipitridae)	*Melierax metabates*	Dark Chanting-goshawk	عقاب مسيرة
252	Accipitriformes	Hawks, Eagles (Accipitridae)	*Micronisus gabar*	Gabar Goshawk	باشق صياد داكن (الباشق الحزين الترتيل)
253	Accipitriformes	Hawks, Eagles (Accipitridae)	*Circus aeruginosus*	Western Marsh-harrier	باشق عابد (باشق قبر)
254	Accipitriformes	Hawks, Eagles (Accipitridae)	*Circus cyaneus*	Hen Harrier	مرزة مستنقعية
255	Accipitriformes	Hawks, Eagles (Accipitridae)	*Circus macrourus*	Pallid Harrier	مرزة الدجاج
256	Accipitriformes	Hawks, Eagles (Accipitridae)	*Circus pygargus*	Montagu's Harrier	مرزة بغثاء (مرزة باهتة)
257	Accipitriformes	Hawks, Eagles (Accipitridae)	*Accipiter badius*	Shikra	مرزة مونتجوية (مرزة أبوشودة)
258	Accipitriformes	Hawks, Eagles (Accipitridae)	*Accipiter brevipes*	Levant Sparrowhawk	بيدق آسيوي (باشق كستنائي)
259	Accipitriformes	Hawks, Eagles (Accipitridae)	*Accipiter nisus*	Eurasian Sparrowhawk	باشق مشرقي
260	Accipitriformes	Hawks, Eagles (Accipitridae)	*Accipiter gentilis*	Northern Goshawk	باشق أوراسي
261	Accipitriformes	Hawks, Eagles (Accipitridae)	*Haliaeetus leucoryphus*	Pallas's Fish-eagle*	باز
262	Accipitriformes	Hawks, Eagles (Accipitridae)	*Haliaeetus albicilla*	White-tailed Sea-eagle*	عقاب السمك بالآسية
263	Accipitriformes	Hawks, Eagles (Accipitridae)	*Milvus migrans*	Black Kite	عقاب عكواء (عقاب البحر أبيض الذيل)
264	Accipitriformes	Hawks, Eagles (Accipitridae)	*Buteo buteo*	Eurasian Buzzard	حدأة سوداء
265	Accipitriformes	Hawks, Eagles (Accipitridae)	*Buteo rufinus*	Long-legged Buzzard	عقيب شائعة (البازي الحواء)
266	Bucerotiformes	Hornbills (Bucerotidae)	*Lophoceros nasutus*	African Grey Hornbill	سقاوة (البازي طويل الساق)
267	Bucerotiformes	Hoopoes (Upupidae)	*Upupa epops*	Common Hoopoe	نساف أرمد أفريقي (أبو معول)
268	Coraciiformes	Bee-eaters (Meropidae)	*Merops albicollis*	White-throated Bee-eater	هدهد أوراسي
269	Coraciiformes	Bee-eaters (Meropidae)	*Merops cyanophrys*	Arabian Green Bee-eater	قارية صدراء (وروار أبيض الزور)
270	Coraciiformes	Bee-eaters (Meropidae)	*Merops persicus*	Blue-cheeked Bee-eater	قارية خضراء (وروار أخضر عربي)
271	Coraciiformes	Bee-eaters (Meropidae)	*Merops apiaster*	European Bee-eater	قارية زرقاء الخدين (وروار أزرق الخد)
272	Coraciiformes	Rollers (Coraciidae)	*Coracias benghalensis*	Indian Roller	قارية أوروبية (وروار أوروبي)
273	Coraciiformes	Rollers (Coraciidae)	*Coracias abyssinicus*	Abyssinian Roller	شقراق هندي
274	Coraciiformes	Rollers (Coraciidae)	*Coracias garrulus*	European Roller	شقراق حبشي
275	Coraciiformes	Kingfishers (Alcedinidae)	*Alcedo atthis*	Common Kingfisher	شقراق أوروبي
276	Coraciiformes	Kingfishers (Alcedinidae)	*Ceryle rudis*	Pied Kingfisher	رفراف شائع
277	Coraciiformes	Kingfishers (Alcedinidae)	*Halcyon smyrnensis*	White-breasted Kingfisher	رفراف أبقع
278	Coraciiformes	Kingfishers (Alcedinidae)	*Halcyon leucocephala*	Grey-headed Kingfisher	رفراف أصدر
279	Coraciiformes	Kingfishers (Alcedinidae)	*Todiramphus chloris*	Collared Kingfisher	رفراف أرمد الرأس
280	Piciformes	Woodpeckers (Picidae)	*Jynx torquilla*	Eurasian Wryneck	رفراف مطوق
281	Piciformes	Woodpeckers (Picidae)	*Dendropicos dorae*	Arabian Woodpecker	لواء أوراسي
282	Falconiformes	Falcons, Caracaras (Falconidae)	*Falco naumanni*	Lesser Kestrel	قراع عربي (نقار الخشب العربي)
283	Falconiformes	Falcons, Caracaras (Falconidae)	*Falco tinnunculus*	Common Kestrel	عويسق
284	Falconiformes	Falcons, Caracaras (Falconidae)	*Falco eleonorae*	Eleonora's Falcon*	عوسق
285	Falconiformes	Falcons, Caracaras (Falconidae)	*Falco concolor*	Sooty Falcon	صقر إليونوري
286	Falconiformes	Falcons, Caracaras (Falconidae)	*Falco columbarius*	Merlin	صقر أسحم (صقر الغروب)
287	Falconiformes	Falcons, Caracaras (Falconidae)	*Falco subbuteo*	Eurasian Hobby	يؤيؤ
288	Falconiformes	Falcons, Caracaras (Falconidae)	*Falco biarmicus*	Lanner Falcon	شويهين أوراسي
289	Falconiformes	Falcons, Caracaras (Falconidae)	*Falco cherrug*	Saker Falcon	صقر وكري
290	Falconiformes	Falcons, Caracaras (Falconidae)	*Falco peregrinus*	Peregrine Falcon	صقر حر
291	Psittaciformes	Parrots (Psittacidae)	*Psittacula eupatria*	Alexandrine Parakeet	كويج (الشاهين)
292	Psittaciformes	Parrots (Psittacidae)	*Psittacula krameri*	Rose-ringed Parakeet	درة إسكندرية (ببغاء نبيلة)
293	Passeriformes	Orioles (Oriolidae)	*Oriolus oriolus*	Eurasian Golden Oriole	درة مطوقة (ببغاء هندية مطوقة)
294	Passeriformes	Bush-shrikes (Malaconotidae)	*Tchagra senegalus*	Black-crowned Tchagra	صفارية أوراسية
295	Passeriformes	Monarch-flycatchers (Monarchidae)	*Terpsiphone viridis*	African Paradise-flycatcher	أخطب أراس
296	Passeriformes	Shrikes (Laniidae)	*Lanius collurio*	Red-backed Shrike	صائد ذباب فردوسي أفريقي
297	Passeriformes	Shrikes (Laniidae)	*Lanius phoenicuroides*	Red-tailed Shrike	دغناش أمغر (صرد أحمر الظهر)
298	Passeriformes	Shrikes (Laniidae)	*Lanius isabellinus*	Isabelline Shrike	صرد أحمر الذيل
299	Passeriformes	Shrikes (Laniidae)	*Lanius vittatus*	Bay-backed Shrike*	دغناش داوري
300	Passeriformes	Shrikes (Laniidae)	*Lanius schach*	Long-tailed Shrike*	دغناش كميت ظهر
301	Passeriformes	Shrikes (Laniidae)	*Lanius minor*	Lesser Grey Shrike	دغناش ذنوب
302	Passeriformes	Shrikes (Laniidae)	*Lanius excubitor*	Great Grey Shrike	صرد صغير
303	Passeriformes	Shrikes (Laniidae)	*Lanius senator*	Woodchat Shrike	صرد كبير
304	Passeriformes	Shrikes (Laniidae)	*Lanius nubicus*	Masked Shrike	دغناش شامي
305	Passeriformes	Crows (Corvidae)	*Pica asirensis*	Asir Magpie	دغناش مبرقع
306	Passeriformes	Crows (Corvidae)	*Corvus ruficollis*	Brown-necked Raven	العقعق العسيري
307	Passeriformes	Crows (Corvidae)	*Corvus rhipidurus*	Fan-tailed Raven	غراب أدرع (غراب بني الرقبة)
308	Passeriformes	Crows (Corvidae)	*Corvus corone*	Carrion Crow*	غداف (غراب مروحي الذيل)
309	Passeriformes	Crows (Corvidae)	*Corvus splendens*	House Crow	غراب جيفي
310	Passeriformes	Penduline-tits (Remizidae)	*Remiz pendulinus*	Eurasian Penduline-tit	غراب دوري
311	Passeriformes	Larks (Alaudidae)	*Alaemon alaudipes*	Greater Hoopoe-lark	قرقفنة أوراسية
312	Passeriformes	Larks (Alaudidae)	*Ramphocoris clotbey*	Thick-billed Lark	مكاء
313	Passeriformes	Larks (Alaudidae)	*Ammomanes cinctura*	Bar-tailed Lark	قبرة شدقاء (قبرة سميكة المنقار)
314	Passeriformes	Larks (Alaudidae)	*Ammomanes deserti*	Desert Lark	حمرة صبغاء
315	Passeriformes	Larks (Alaudidae)	*Eremopterix nigriceps*	Black-crowned Sparrow-lark	حمرة صحراوية (قبرة صحراوية)
316	Passeriformes	Larks (Alaudidae)	*Mirafra javanica*	Horsfield's Bushlark	أكبد أسود تاج (قبرة سوداء متوجة)
317	Passeriformes	Larks (Alaudidae)	*Eremalauda eremodites*	Arabian Lark	حمرة شجرية (قبرة الشجر)
318	Passeriformes	Larks (Alaudidae)	*Alaudala rufescens*	Lesser Short-toed Lark	قبرة عربية
319	Passeriformes	Larks (Alaudidae)	*Melanocorypha bimaculata*	Bimaculated Lark	قبرة صبيعاء صغيرة
320	Passeriformes	Larks (Alaudidae)	*Melanocorypha calandra*	Calandra Lark*	عليعل (قبرة شرقية صغيرة)
321	Passeriformes	Larks (Alaudidae)	*Calandrella brachydactyla*	Greater Short-toed Lark	علعل (قبرة شرقية)
322	Passeriformes	Larks (Alaudidae)	*Calandrella eremica*	Rufous-capped Lark	قبرة صبيعاء عربية
323	Passeriformes	Larks (Alaudidae)	*Eremophila bilopha*	Temminck's Lark	قبرة صبيعاء كبيرة
324	Passeriformes	Larks (Alaudidae)	*Lullula arborea*	Woodlark*	حمرة قرناء صحراوية)قبرة مقرنة(
325	Passeriformes	Larks (Alaudidae)	*Alauda arvensis*	Eurasian Skylark	قبرة غابية
326	Passeriformes	Larks (Alaudidae)	*Alauda gulgula*	Oriental Skylark	قبرة سماوية أوراسية
327	Passeriformes	Larks (Alaudidae)	*Galerida cristata*	Crested Lark	قبرة سماوية مشرقية
328	Passeriformes	Cisticolas and Allies (Cisticolidae)	*Cisticola juncidis*	Zitting Cisticola	قبرة شائعة (قبرة متوجة)

329	Passeriformes	Cisticolas and Allies (Cisticolidae)	*Prinia gracilis*	Graceful Prinia	نمنة مخططة
330	Passeriformes	Reed-warblers (Acrocephalidae)	*Arundinax aedon*	Thick-billed Warbler*	نمنة ذنوب
331	Passeriformes	Reed Warblers (Acrocephalidae)	*Iduna caligata*	Booted Warbler*	دخلة سميكة المنقار
332	Passeriformes	Reed Warblers (Acrocephalidae)	*Iduna rama*	Sykes's Warbler*	دخناء سوقاء
333	Passeriformes	Reed Warblers (Acrocephalidae)	*Iduna pallida*	Olivaceous Warbler	دخناء سايكسية
334	Passeriformes	Reed Warblers (Acrocephalidae)	*Hippolais languida*	Upcher's Warbler	دخناء زيتونية شرقية
335	Passeriformes	Reed Warblers (Acrocephalidae)	*Hippolais olivetorum*	Olive-tree Warbler	دخناء وادية
336	Passeriformes	Reed Warblers (Acrocephalidae)	*Hippolais icterina*	Icterine Warbler	دخناء شجر زيتون
337	Passeriformes	Reed Warblers (Acrocephalidae)	*Acrocephalus melanopogon*	Moustached Warbler	دخناء ليمونية
338	Passeriformes	Reed Warblers (Acrocephalidae)	*Acrocephalus schoenobaenus*	Sedge Warbler	دخناء مشورية
339	Passeriformes	Reed Warblers (Acrocephalidae)	*Acrocephalus dumetorum*	Blyth's Reed-warbler	دخناء سعدية
340	Passeriformes	Reed Warblers (Acrocephalidae)	*Acrocephalus palustris*	Marsh Warbler	دخناء إيلايثية
341	Passeriformes	Reed Warblers (Acrocephalidae)	*Acrocephalus scirpaceus*	Common Reed-warbler	دخناء مستنقعية
342	Passeriformes	Reed Warblers (Acrocephalidae)	*Acrocephalus griseldis*	Basra Reed-Warbler	دخناء أوراسية
343	Passeriformes	Reed Warblers (Acrocephalidae)	*Acrocephalus arundinaceus*	Great Reed-warbler	دخناء بصرية
344	Passeriformes	Reed Warblers (Acrocephalidae)	*Acrocephalus stentoreus*	Clamorous Reed-warbler	دخناء كبيرة
345	Passeriformes	Grasshopper-warblers and Grassbirds (Locustellidae)	*Locustella luscinioides*	Savi's Warbler	دخناء صخباء
346	Passeriformes	Grasshopper-warblers and Grassbirds (Locustellidae)	*Locustella fluviatilis*	River Warbler*	دخلة سافية
347	Passeriformes	Grasshopper-warblers and Grassbirds (Locustellidae)	*Locustella naevia*	Common Grasshopper-warbler	دخلة نهرية
348	Passeriformes	Swallows and Martins (Hirundinidae)	*Delichon urbicum*	Northern House Martin	دخلة جندبية شائعة
349	Passeriformes	Swallows and Martins (Hirundinidae)	*Cecropis daurica*	Red-rumped Swallow	خطاف عجز
350	Passeriformes	Swallows and Martins (Hirundinidae)	*Hirundo rustica*	Barn Swallow	سنونو أحمرعجز
351	Passeriformes	Swallows and Martins (Hirundinidae)	*Ptyonoprogne rupestris*	Eurasian Crag Martin	سنونو شائع
352	Passeriformes	Swallows and Martins (Hirundinidae)	*Ptyonoprogne obsoleta*	Pale Rock Martin	عوهق جرفي أوراسي (خطاف الشواهق الأوروبي)
353	Passeriformes	Swallows and Martins (Hirundinidae)	*Neophedina cincta*	Banded Martin*	عوهق جرفي فاتم (خطاف الشواهق الباهت)
354	Passeriformes	Swallows and Martins (Hirundinidae)	*Riparia paludicola*	African Plain Martin*	خطاف مشرط
355	Passeriformes	Swallows and Martins (Hirundinidae)	*Riparia riparia*	Collared Sand Martin	خطاف بني زور (خطاف السهول الأفريقي)
356	Passeriformes	Bulbuls (Pycnonotidae)	*Pycnonotus leucotis*	White-eared Bulbul	خطاف رملي
357	Passeriformes	Bulbuls (Pycnonotidae)	*Pycnonotus cafer*	Red-vented Bulbul	بلبل أغشى
358	Passeriformes	Bulbuls (Pycnonotidae)	*Pycnonotus xanthopygos*	White-spectacled Bulbul	بلبل أكسع (بلبل أحمر العجز)
359	Passeriformes	Leaf-warblers (Phylloscopidae)	*Phylloscopus orientalis*	Eastern Bonelli's Warbler*	كعيت (بلبل أصفر العجز)
360	Passeriformes	Leaf-warblers (Phylloscopidae)	*Phylloscopus sibilatrix*	Wood Warbler	دخلة بونلية شرقية (نقشارة بوننللي الشرقية)
361	Passeriformes	Leaf-warblers (Phylloscopidae)	*Phylloscopus inornatus*	Yellow-browed Warbler*	دخلة غابية (نقشارة الغاب)
362	Passeriformes	Leaf-warblers (Phylloscopidae)	*Phylloscopus humei*	Hume's Leaf-warbler*	دخلة صفراء حاجب
363	Passeriformes	Leaf-warblers (Phylloscopidae)	*Phylloscopus fuscatus*	Dusky Warbler*	دخلة إهيومية
364	Passeriformes	Leaf-warblers (Phylloscopidae)	*Phylloscopus trochilus*	Willow Warbler	دخلة معتمة
365	Passeriformes	Leaf-warblers (Phylloscopidae)	*Phylloscopus collybita*	Common Chiffchaff	دخلة صفصافية
366	Passeriformes	Leaf-warblers (Phylloscopidae)	*Phylloscopus tristis*	Siberian Chiffchaff	دخلة شائعة (نقشارة)
367	Passeriformes	Leaf-warblers (Phylloscopidae)	*Phylloscopus umbrovirens*	Brown Woodland-warbler	دخلة سيبيرية
368	Passeriformes	Leaf-warblers (Phylloscopidae)	*Phylloscopus nitidus*	Green Warbler*	دخلة غابية بنية
369	Passeriformes	Leaf-warblers (Phylloscopidae)	*Phylloscopus borealis*	Arctic Warbler*	دخلة خضراء
370	Passeriformes	Bush Warblers (Scotocercidae)	*Scotocerca inquieta*	Streaked Scrub-warbler	دخلة قطبية شمالية

371	Passeriformes	Old World Warblers and Parrotbills (Sylviidae)	*Sylvia atricapilla*	Eurasian Blackcap	دخلة شجيرية (نمنة الشجر)
372	Passeriformes	Old World Warblers and Parrotbills (Sylviidae)	*Sylvia borin*	Garden Warbler	هازجة مقلنسة أوراسية (أبو قلنسوة)
373	Passeriformes	Old World Warblers and Parrotbills (Sylviidae)	*Sylvia nana*	Asian Desert Warbler	هازجة حدائقية
374	Passeriformes	Old World Warblers and Parrotbills (Sylviidae)	*Sylvia nisoria*	Barred Warbler	هازجة صحراوية آسيوية
375	Passeriformes	Old World Warblers and Parrotbills (Sylviidae)	*Sylvia leucomelaena*	Arabian Warbler	هازجة كحلاء
376	Passeriformes	Old World Warblers and Parrotbills (Sylviidae)	*Sylvia crassirostris*	Eastern Orphean Warbler	هازجة عربية
377	Passeriformes	Old World Warblers and Parrotbills (Sylviidae)	*Sylvia buryi*	Yemen Warbler	هازجة حدائقية شرقية
378	Passeriformes	Old World Warblers and Parrotbills (Sylviidae)	*Sylvia curruca*	Lesser Whitethroat	هازجة يمنية
379	Passeriformes	Old World Warblers and Parrotbills (Sylviidae)	*Sylvia mystacea*	Ménétries's Warbler	زوراء صغيرة
380	Passeriformes	Old World Warblers and Parrotbills (Sylviidae)	*Sylvia melanothorax*	Cyprus Warbler*	هازجة رأساء
381	Passeriformes	Old World Warblers and Parrotbills (Sylviidae)	*Sylvia melanocephala*	Sardinian Warbler	هازجة قبرصية
382	Passeriformes	Old World Warblers and Parrotbills (Sylviidae)	*Sylvia cantillans*	Subalpine warbler	هازجة سردينية
383	Passeriformes	Old World Warblers and Parrotbills (Sylviidae)	*Sylvia ruppeli*	Rüppell's Warbler	هازجة مغردة شرقية
384	Passeriformes	Old World Warblers and Parrotbills (Sylviidae)	*Sylvia communis*	Common Whitethroat	هازجة روبلية
385	Passeriformes	White-eyes (Zosteropidae)	*Zosterops abyssinicus*	Abyssinian White-eye	زوراء شائعة
386	Passeriformes	Laughingthrushes and allies (Leiotrichidae)	*Argya squamiceps*	Arabian Babbler	مغربة حبشية (أبيض العين الحبشي)
387	Passeriformes	Starlings (Sturnidae)	*Sturnus vulgaris*	Common Starling	بلنصي عربي
388	Passeriformes	Starlings (Sturnidae)	*Pastor roseus*	Rosy Starling	زرزور شائع
389	Passeriformes	Starlings (Sturnidae)	*Acridotheres tristis*	Common Myna	زرزور ورد
390	Passeriformes	Starlings (Sturnidae)	*Acridotheres ginginianus*	Bank Myna	ماينا شائعة
391	Passeriformes	Starlings (Sturnidae)	*Onychognathus tristramii*	Tristram's Starling	ماينا ضفافية
392	Passeriformes	Starlings (Sturnidae)	*Cinnyricinclus leucogaster*	Violet-backed Starling	ضوعة (زرزور أسود)
393	Passeriformes	Thrushes (Turdidae)	*Turdus viscivorus*	Mistle Thrush*	زرزور مجوف
394	Passeriformes	Thrushes (Turdidae)	*Turdus philomelos*	Song Thrush	سمنة دبقية
395	Passeriformes	Thrushes (Turdidae)	*Turdus iliacus*	Redwing	سمنة مغردة
396	Passeriformes	Thrushes (Turdidae)	*Turdus merula*	Eurasian Blackbird	حمراء جناح
397	Passeriformes	Thrushes (Turdidae)	*Turdus menachensis*	Yemen Thrush	شحرور أوراسي
398	Passeriformes	Thrushes (Turdidae)	*Turdus pilaris*	Fieldfare	سمنة يمنية
399	Passeriformes	Thrushes (Turdidae)	*Turdus eunomus*	Dusky Thrush*	سمنة حقلية
400	Passeriformes	Thrushes (Turdidae)	*Turdus torquatus*	Ring Ouzel*	سمنة مطوقة
401	Passeriformes	Thrushes (Turdidae)	*Turdus atrogularis*	Black-throated Thrush	سمنة معتمة
402	Passeriformes	Old World Flycatchers (Muscicapidae)	*Cercotrichas galactotes*	Rufous-tailed Scrub-robin	سمنة سوداء زور
403	Passeriformes	Old World Flycatchers (Muscicapidae)	*Cercotrichas podobe*	Black Scrub-robin	شوالة (أبو الحناء الأحمر)
404	Passeriformes	Old World Flycatchers (Muscicapidae)	*Muscicapa gambagae*	Gambaga Flycatcher	سوادية (أبو الحناء الأسود)
405	Passeriformes	Old World Flycatchers (Muscicapidae)	*Muscicapa striata*	Spotted Flycatcher	صائد ذباب جامباجي
406	Passeriformes	Old World Flycatchers (Muscicapidae)	*Erithacus rubecula*	European Robin	صائد ذباب أرقط
407	Passeriformes	Old World Flycatchers (Muscicapidae)	*Irania gutturalis*	White-throated Robin	حنائي أوروبي
408	Passeriformes	Old World Flycatchers (Muscicapidae)	*Cyanecula svecica*	Bluethroat	حنائي أزور
409	Passeriformes	Old World Flycatchers (Muscicapidae)	*Luscinia luscinia*	Thrush Nightingale	زرقاء زور
410	Passeriformes	Old World Flycatchers (Muscicapidae)	*Luscinia megarhynchos*	Common Nightingale	العندليب

411	Passeriformes	Old World Flycatchers (Muscicapidae)	*Ficedula parva*	Red-breasted Flycatcher	هزار شائع
412	Passeriformes	Old World Flycatchers (Muscicapidae)	*Ficedula semitorquata*	Semi-collared Flycatcher	صائد ذباب أحمر الصدر
413	Passeriformes	Old World Flycatchers (Muscicapidae)	*Ficedula albicollis*	Collared Flycatcher*	صائد ذباب شبه مطوق
414	Passeriformes	Old World Flycatchers (Muscicapidae)	*Phoenicurus erythronotus*	Eversmann's Redstart	صائد ذباب تايجي
415	Passeriformes	Old World Flycatchers (Muscicapidae)	*Phoenicurus ochruros*	Black Redstart	حميراء عصماء
416	Passeriformes	Old World Flycatchers (Muscicapidae)	*Phoenicurus phoenicurus*	Common Redstart	حميراء سوداء
417	Passeriformes	Old World Flycatchers (Muscicapidae)	*Monticola saxatilis*	Rufous-tailed Rock-thrush	حميراء شائعة
418	Passeriformes	Old World Flycatchers (Muscicapidae)	*Monticola solitarius*	Blue Rock-thrush	سمنة صخرية
419	Passeriformes	Old World Flycatchers (Muscicapidae)	*Monticola rufocinereus*	Little Rock-thrush	سمنة صخرية زرقاء
420	Passeriformes	Old World Flycatchers (Muscicapidae)	*Saxicola rubetra*	Whinchat	سمنة صخرية صغيرة
421	Passeriformes	Old World Flycatchers (Muscicapidae)	*Saxicola caprata*	Pied Bushchat*	برقش أحمر (القليعي)
422	Passeriformes	Old World Flycatchers (Muscicapidae)	*Saxicola torquatus*	Common Stonechat	برقش أبقع (القليعي الأبقع)
423	Passeriformes	Old World Flycatchers (Muscicapidae)	*Oenanthe oenanthe*	Northern Wheatear	برقش (القليعي الشائع)
424	Passeriformes	Old World Flycatchers (Muscicapidae)	*Oenanthe bottae*	Buff-breasted Wheatear	أبلق شمالي
425	Passeriformes	Old World Flycatchers (Muscicapidae)	*Oenanthe isabellina*	Isabelline Wheatear	أبلق أحمر صدر
426	Passeriformes	Old World Flycatchers (Muscicapidae)	*Oenanthe monacha*	Hooded Wheatear	أبلق درجي (أبلق أشهب)
427	Passeriformes	Old World Flycatchers (Muscicapidae)	*Oenanthe deserti*	Desert Wheatear	أبلق مقلنس
428	Passeriformes	Old World Flycatchers (Muscicapidae)	*Oenanthe hispanica*	Black-eared Wheatear	أبلق صحراوي
429	Passeriformes	Old World Flycatchers (Muscicapidae)	*Oenanthe cypriaca*	Cyprus Wheatear	أبلق أغشى شرقي
430	Passeriformes	Old World Flycatchers (Muscicapidae)	*Oenanthe pleschanka*	Pied Wheatear	أبلق قبرصي
431	Passeriformes	Old World Flycatchers (Muscicapidae)	*Oenanthe moesta*	Buff-rumped Wheatear*	أبلق أبقع
432	Passeriformes	Old World Flycatchers (Muscicapidae)	*Oenanthe melanura*	Blackstart	أبلق أحمر عجز
433	Passeriformes	Old World Flycatchers (Muscicapidae)	*Oenanthe picata*	Variable Wheatear*	أبلق أسود الذنب
434	Passeriformes	Old World Flycatchers (Muscicapidae)	*Oenanthe leucopyga*	White-crowned wheatear	أبلق متغير
435	Passeriformes	Old World Flycatchers (Muscicapidae)	*Oenanthe finschii*	Finsch's Wheatear	أبلق أبيض قنة
436	Passeriformes	Old World Flycatchers (Muscicapidae)	*Oenanthe lugens*	Mourning Wheatear	أبلق فينشي
437	Passeriformes	Old World Flycatchers (Muscicapidae)	*Oenanthe chrysopygia*	Red-tailed Wheatear	أبلق حزين شرقي
438	Passeriformes	Old World Flycatchers (Muscicapidae)	*Oenanthe xanthoprymna*	Kurdish Wheatear	أبلق أحمرذنب
439	Passeriformes	Hypocolius (Hypocoliidae)	*Hypocolius ampelinus*	Hypocolius	أبلق كردي
440	Passeriformes	Sunbirds (Nectariniidae)	*Hedydipna metallica*	Nile Valley Sunbird	سوداء (الخناق الرمادي)
441	Passeriformes	Sunbirds (Nectariniidae)	*Cinnyris osea*	Palestine Sunbird	تمير نيلي
442	Passeriformes	Sunbirds (Nectariniidae)	*Cinnyris hellmayri*	Arabian Sunbird	تمير فلسطيني
443	Passeriformes	Weavers (Ploceidae)	*Ploceus galbula*	Rüppell's Weaver	تمير عربي
444	Passeriformes	Weavers (Ploceidae)	*Ploceus manyar*	Streaked Weaver	تبشر (نساج روبلي)
445	Passeriformes	Weavers (Ploceidae)	*Ploceus philippinus*	Baya Weaver	تبشر مخطط (نساج مخطط)
446	Passeriformes	Waxbills (Estrildidae)	*Estrilda rufibarba*	Arabian Waxbill	تبشر بايا (نساج كستنائي)
447	Passeriformes	Waxbills (Estrildidae)	*Amandava amandava*	Red Avadavat	شمعي المنقار العربي
448	Passeriformes	Waxbills (Estrildidae)	*Euodice cantans*	African Silverbill	مونيا حمراء (شمعي المنقار الأحمر)
449	Passeriformes	Waxbills (Estrildidae)	*Euodice malabarica*	Indian Silverbill	فضي المنقار الأفريقي
450	Passeriformes	Waxbills (Estrildidae)	*Lonchura punctulata*	Scaly-breasted Munia	فضي المنقار الهندي
451	Passeriformes	Old World Sparrows (Passeridae)	*Passer domesticus*	House Sparrow	مونيا محرشفة صدر
452	Passeriformes	Old World Sparrows (Passeridae)	*Passer hispaniolensis*	Spanish Sparrow	عصفور دوري
453	Passeriformes	Old World Sparrows (Passeridae)	*Passer moabiticus*	Dead Sea Sparrow*	عصفور أسباني
454	Passeriformes	Old World Sparrows (Passeridae)	*Passer euchlorus*	Arabian Golden Sparrow	عصفور البحر الميت
455	Passeriformes	Old World Sparrows (Passeridae)	*Carpospiza brachydactyla*	Pale Sparrow	عصفور مذهب عربي
456	Passeriformes	Old World Sparrows (Passeridae)	*Gymnoris xanthocollis*	Chestnut-shouldered Bush-sparrow*	عصفور صخري شاحب
457	Passeriformes	Pipits and Wagtails (Motacillidae)	*Anthus trivialis*	Tree Pipit	عصفور أصفر زور
458	Passeriformes	Pipits and Wagtails (Motacillidae)	*Anthus hodgsoni*	Olive-backed Pipit*	جشنة شجرية (تميرة الشجر)
459	Passeriformes	Pipits and Wagtails (Motacillidae)	*Anthus cervinus*	Red-throated Pipit	جشنة زيتونية ظهر
460	Passeriformes	Pipits and Wagtails (Motacillidae)	*Anthus pratensis*	Meadow Pipit	جشنة حمراء زور
461	Passeriformes	Pipits and Wagtails (Motacillidae)	*Anthus spinoletta*	Water Pipit	جشنة مروجية (تميرة الحقول)
462	Passeriformes	Pipits and Wagtails (Motacillidae)	*Anthus richardi*	Richard's Pipit*	جشنة مائية (تميرة الماء)
463	Passeriformes	Pipits and Wagtails (Motacillidae)	*Anthus campestris*	Tawny Pipit	جشنة ريتشاردية
464	Passeriformes	Pipits and Wagtails (Motacillidae)	*Anthus cinnamomeus*	African Pipit	جشنة صحماء (تميرة الصحراء)
465	Passeriformes	Pipits and Wagtails (Motacillidae)	*Anthus similis*	Long-billed Pipit	جشنة أفريقية
466	Passeriformes	Pipits and Wagtails (Motacillidae)	*Motacilla flava*	Western Yellow Wagtail	جشنة خطماء (تميرة طويلة المنقار)
467	Passeriformes	Pipits and Wagtails (Motacillidae)	*Motacilla cinerea*	Grey Wagtail	ذعرة صفراء
468	Passeriformes	Pipits and Wagtails (Motacillidae)	*Motacilla citreola*	Citrine Wagtail	ذعرة رمداء
469	Passeriformes	Pipits and Wagtails (Motacillidae)	*Motacilla alba*	White Wagtail	ذعرة ليمونية
470	Passeriformes	Finches (Fringillidae)	*Fringilla coelebs*	Common Chaffinch*	ذعرة بيضاء
471	Passeriformes	Finches (Fringillidae)	*Fringilla montifringilla*	Brambling	شرشور ظالم (حسون القش)
472	Passeriformes	Finches (Fringillidae)	*Coccothraustes coccothraustes*	Hawfinch*	شرشور جبلي (حسون جبلي)
473	Passeriformes	Finches (Fringillidae)	*Carpodacus erythrinus*	Common Rosefinch	أشدق كرزي (حسون الكرز)
474	Passeriformes	Finches (Fringillidae)	*Carpodacus synoicus*	Sinai Rosefinch	حسون ورد سائغ
475	Passeriformes	Finches (Fringillidae)	*Bucanetes githagineus*	Trumpeter Finch	حسون ورد سيناوي
476	Passeriformes	Finches (Fringillidae)	*Rhodospiza obsoleta*	Desert Finch	حسون كزبري (زمير وردي)
477	Passeriformes	Finches (Fringillidae)	*Rhynchostruthus percivali*	Arabian Grosbeak	حسون صحراوي
478	Passeriformes	Finches (Fringillidae)	*Chloris chloris*	European Greenfinch*	أشدق عربي
479	Passeriformes	Finches (Fringillidae)	*Crithagra rothschildi*	Arabian Serin	حسون أخضر
480	Passeriformes	Finches (Fringillidae)	*Crithagra menachensis*	Yemen Serin	نعار عربي
481	Passeriformes	Finches (Fringillidae)	*Linaria cannabina*	Common Linnet	نعار يمني
482	Passeriformes	Finches (Fringillidae)	*Linaria yemenensis*	Yemen Linnet	حسون تفاحي
483	Passeriformes	Finches (Fringillidae)	*Carduelis carduelis*	European Goldfinch	حسون تفاحي يمني
484	Passeriformes	Finches (Fringillidae)	*Serinus pusillus*	Red-fronted Serin*	حسون مذهب أوروبي
485	Passeriformes	Finches (Fringillidae)	*Spinus spinus*	Eurasian Siskin	نعار أحمر الجبهة
486	Passeriformes	Buntings and New World Sparrows (Emberizidae)	*Emberiza melanocephala*	Black-headed Bunting	حسون شوكي
487	Passeriformes	Buntings and New World Sparrows (Emberizidae)	*Emberiza bruniceps*	Red-headed Bunting*	درسة رأساء
488	Passeriformes	Buntings and New World Sparrows (Emberizidae)	*Emberiza calandra*	Corn Bunting	درسة حمراء رأس
489	Passeriformes	Buntings and New World Sparrows (Emberizidae)	*Emberiza cia*	Rock Bunting*	درسة قمحية
490	Passeriformes	Buntings and New World Sparrows (Emberizidae)	*Emberiza cineracea*	Cinereous Bunting	درسة صخرية
491	Passeriformes	Buntings and New World Sparrows (Emberizidae)	*Emberiza hortulana*	Ortolan Bunting	درسة ذقناء غربية
492	Passeriformes	Buntings and New World Sparrows (Emberizidae)	*Emberiza caesia*	Cretzschmar's Bunting	درسة شعيرية
493	Passeriformes	Buntings and New World Sparrows (Emberizidae)	*Emberiza leucocephalos*	Pine Bunting*	درسة زرقاء
494	Passeriformes	Buntings and New World Sparrows (Emberizidae)	*Emberiza striolata*	Striolated Bunting	درسة صنوبرية
495	Passeriformes	Buntings and New World Sparrows (Emberizidae)	*Emberiza tahapisi*	Cinnamon-breasted Bunting	درسة رفيعة تخطيط
496	Passeriformes	Buntings and New World Sparrows (Emberizidae)	*Emberiza schoeniclus*	Reed Bunting*	درسة قرفية صدر
497	Passeriformes	Buntings and New World Sparrows (Emberizidae)	*Emberiza aureola*	Yellow-breasted Bunting*	درسة قصبية
498	Passeriformes	Buntings and New World Sparrows (Emberizidae)	*Emberiza rustica*	Rustic Bunting*	درسة صفراء صدر
499	Passeriformes	Buntings and New World Sparrows (Emberizidae)	*Emberiza pusilla*	Little Bunting*	درسة صدآء (درسة الريف)
					درسة صغيرة

NOTES

GUIDE TO VOLUME 1:

1 www.iucnredlist.org: BirdLife International 2019a.
2 Symes et al. 2015.
3 BirdLife International 2019a.
4 Symes et al. 2015.
5 Jennings 2010.
6 www.hbw.com.

CHAPTER 1

1 Heat maps were devised using ARCGIS 10.6.1 by overlaying individual species' range maps from the species accounts shown in Volume 2. Range map polygons were clipped according to each species' elevation range limits. To eliminate unnaturally hard boundaries between adjoining areas, species counts were then interpolated to create the heat map. Locations with more species are depicted in redder colors. Locations with fewer species are depicted in greener colors.
2 Fagan and Holmes 2006; Blomqvist et al. 2010.
3 Symes et al. 2015.
4 Breeding population estimates are from Jennings 2010.
5 Ibid.
6 Population trend data are from the IUCN. A further 34 Saudi Arabian species are listed by the IUCN as having unknown regional population status while the regional status of the remaining 153 species regularly recorded in Saudi Arabia has not yet been assessed by the IUCN. Breeding population estimates are from Jennings 2010.
7 Each species was assigned one of the following scores based on its regional population trend as assessed by the IUCN: 1 = increasing; 0.5 = possibly increasing; 0 = stable; -0.5 = possibly decreasing; -1 = decreasing; and -2 = very rapid decline. Values greater than 0 indicate species are increasing, values below 0 indicate species are decreasing, while 0 indicates species are stable. Sample sizes for each habitat type are as follows: settled areas: n=14; coastal and pelagic: n=23; farmlands: n=26; highlands: n=21; arid areas / acacia scrub: n=78; wetlands: n=26. There are no significant differences between the numbers of birds breeding in each habitat type (ANOVA: F5,188=1.5, P=0.2); however, there are statistically significant differences in the population trends of species according to habitat type (ANOVA: F5,188=8.7, P<0.001).

Species existing mainly in human habitats (farmlands, settled areas, parklands and wetlands) are likely to be increasing (mean=0.36) whereas species existing in relatively natural habitats (arid areas, scrublands, highlands, coastal areas, and offshore) are more likely to be declining (mean=-0.19; ANOVA: F1,188=37.7, P<0.0001). Furthermore, birds in natural habitats tend to have a poorer conservation status than birds in modified habitats, however this difference was not quite statistically significant (ANOVA: F1,188=3.5, P=0.06).
8 See endnote 5 for methods.
9 Heavier birds are more likely to be decreasing than lighter birds (ANOVA: F2,206=13.2, P<0.0001). Likewise, taller birds are more likely to be decreasing than smaller birds (ANOVA: F2,223=11.3, P<0.0001). Furthermore, both larger and heavier birds have a poorer regional conservation status (Body size: linear regression, F1,258=14.8, P<0.001; body weight: linear regression, F1,238=14.8, P<0.001). Ostrich was not included in these analyses as it only occurs in fenced protected areas and is such an outlier in terms of body weight, but including it does not alter the outcome. The same patterns emerge when the sample is restricted to breeding birds only. Birds assessed by the IUCN as "possibly increasing", "possibly decreasing" and "possibly stable" are treated here as "increasing", "decreasing" and "stable", respectively. Sample sizes for body size are as follows: Decreasing = 47, Stable = 120, Increasing = 56).
10 Tieleman et al. 2004; Lepage and Lloyd 2004.
11 Regionally declining species were assigned a score of -1, regionally stable species 0, and regionally increasing species 1. Species distribution maps were overlain on the map and aggregate scores were calculated for each location in the Kingdom. Maximum overall score was 29, minimum overall score was -9.
12 NCWCD 2003.
13 Symes et al. 2015.
14 Babbington and Roberts 2017.

CHAPTER 2

1 Magige et al. 2009; Jennings 2010.
2 Jones 2011.
3 al-Boug unpubl. data
4 Homerin 1985.
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7 Stewart and Stewart 2015.
7 Epstein 1943; Stewart and Stewart 2015.
9 Dickson 1949.
10 Oddy 1991.
11 Clark 2004.
12 Ibid.
13 Sokolov et al. 2016.
14 Samour and Naldo 2005.
15 Shobrak 2015.
16 Barton 2000; Enderson 2008; Seddon and Launay 2008; Shobrak 2015.
17 Sokolov et al. 2016.

CHAPTER 3

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2 Jennings 2010.
3 Ibid.
4 Bruckner et al. 2013.
5 Kathiresan and Bingham 2001.
6 Nagelkerken et al. 2008.
7 Babbington et al. 2019.
8 Babbington and Roberts 2014.
9 Jennings 2010.
10 Almahasheer et al. 2016.
11 Jennings 2010.
12 Ibid.
13 Ibid.
14 Jennings et al. 2010.
15 Jennings 2010.
16 Miller and Cope 1996.
17 Hegazy et al. 1998.
18 Edgell 2006.
19 UNEP-WCMC 2013.
20 Jennings 2010.
21 Ibid.
22 Bird Life International 1998.
23 Jennings 2010.
24 Bird Life International 2016.
25 Miller and Cope 1996.
26 Augustin et al. 2014.
27 Alatar et al. 2012.
28 Adgaba et al. 2016.
29 Khalik et al. 2013.
30 Alatar et al. 2012.
31 Osman et al. 2014.
32 Probert et al. 2009.
33 Shaltout et al. 1997; El-Sheikh et al. 2013; Al-Rowaily et al. 2015.
34 Formerly known as Mahazat as-Sayd Protected Area.
35 Al-Sodany et al. 2011.
36 Islam and Knutson 2008.
37 Saudi Geological Survey 2016.
38 Jennings 2010.
39 Ibid.
40 Ibid.
41 Ibid.
42 Gavashelishvili et al. 2012; Yamac and Bilgin 2012.
43 Jennings 2010.
44 Ibid.
45 Mandaville 1986.
46 Ibid; Miller and Cope 1996.
47 Jennings 2010.
48 Hoyland 2001
49 Jennings 2010
50 Ibid.
51 Miller 2011; Burt 2014.
52 Saenger 2011.
53 Abuelgasim and Alhosani 2014.
54 Symens and Alsuhaibany 1996.
55 Ibid.
56 Miller 2011.
57 Jennings 2010.
58 Chace and Walsh 2006.
59 Macdougall and Turkington 2005; Grarock et al. 2013.
60 Jennings 2010.
61 Alhashimi, unpublished data.
62 Boland et al. 2017.
63 Gahbauer et al. 2015.
64 Jennings 2010.
65 Burwell and Boland, unpublished data.
66 Jennings 1999.
67 Jennings 2010.
68 Ibid.
69 Ibid.
70 Ibid.
71 Ibid.
72 Jennings 1999.
73 Babbington and Roberts 2017.
74 Kempe and Driks 2008.
75 Jennings 2010.
76 Newton and Symens 1995; Jennings 2010.
77 Jennings 2010.

CHAPTER 4

1 This figure is calculated by summing all of the estimated annual breeding population sizes (as provided in Volume 2) for each of the 219 breeding species of Saudi Arabia.
2 Larger birds commence breeding earlier in the season (Linear regression: F1,208=9.3, P<0.001). The same relationship holds for heavier birds (Linear regression: F1,205=3.6, P=0.004), and when seabirds are excluded from the analysis (Linear Regression: F1,195=9.4, P<0.001). NB: this analysis does not take into account phylogenetic considerations.
3 Shobrak 1998.
4 Williams et al. 1999.
5 Champagne et al. 2012.
6 Williams and Tieleman 2005; Haugen et al. 2003.
7 Tieleman et al. 2002; 2003.
8 Tieleman et al. 2004.
9 Leader and Yom-tov 1998.
10 Ibid.
11 Stagg 1992.
12 Ibid.
13 Ibid.
14 Ibid.
15 Newton and Newton 1996; Shobrak 1996.
16 Newton and Newton 1996.
17 Shobrak 1996.
18 Shobrak 2001.
19 Shobrak 1996; 2001.
20 Newton and Newton 1996.
21 Ibid.
22 Al-Suhaibany 1995.
23 Amat and Masero 2009.
24 Al-Suhaibany 1995.
25 Ibid.
26 Modified from Al-Suhaibany 1995.
27 Al-Suhaibany 1995.
28 Gil and Gahr 2002.
29 Martín-Vivaldi et al. 2000.
30 Martín-Vivaldi et al. 2002.
31 Martín-Vivaldi et al. 1999; 2004.
32 Zilberman et al. 2001a; 2001b.
33 Berger et al. 2014.
34 Ibid.
35 Zilberman et al. 2001a.
36 Goldstein et al. 1986.
37 Berger et al. 2014.
38 Griffith et al. 2002.
39 Møller and Birkhead 1994.
40 Friedman and Remeš 2016.
41 Keynan and Yosef 2010; Antczak et al. 2012.
42 Yosef and Pinshow 1989; 2005.

CHAPTER 5

1 Kirby et al. 2008.
2 Note these 291 species include some species that also have resident breeding populations within Saudi Arabia. Hence the apparent discrepancy between this figure and the number of non-breeding species presented in Chapter 1 is not an error.
3 Gavashelishvili et al. 2012; Yamac and Bilgin 2012.
4 Birdlife International 2010a.
5 Ibid.
6 Birdlife International 2010b.
7 Pearson and Lack 1992; Tøttrup et al. 2012; Koleček et al. 2016.
8 Tøttrup et al. 2012.
9 Ibid.
10 BirdLife International 2010c.
11 Vágási et al. 2016.
12 Minias et al. 2015.
13 Kaboli et al. 2007.
14 La Sorte et al. 2013.
15 Klaassen et al. 2011.
16 Spaar 1997.
17 Sapir et al. 2010.
18 Mellone et al. 2011.
19 Buechley et al. 2018.
20 Evans 1994.

21 Schmaljohann et al. 2008.
22 Engel et al. 2006.
23 Adamík et al. 2016.
24 Bairlein 1985.
25 Biebach et al. 1986.
26 Liechti and Schaller 1999.
27 Scott 2011.
28 Sapir et al. 2004.
29 Barboutis et al. 2014.
30 Gill et al. 2009; Piersma 1998.
31 Witter and Cuthill 1993; Dietz et al. 2007.
32 Kullberg et al. 1996.
33 Bauchinger et al. 2005.
34 Kvist and Lindström 2003.
35 Bauchinger et al. 2005.
36 Bauchinger et al. 2009.
37 Åkesson et al. 2012.
38 Klaassen et al. 2012.
39 Schmaljohann et al. 2012; Bairlein et al. 2012; 2015.
40 Currie et al. 2000; Pärt 2001.
41 Currie et al. 2000.
42 Ibid.
43 Schmaljohann et al. 2012.
44 Arlt et al. 2015.
45 Schmaljohann et al. 2013.
46 Arizaga et al. 2011; Bairlein et al. 2012; 2015.
47 Hasselquist 1998; Hasselquist and Bensch 2008; Węgrzyn et al. 2010.
48 Bensch and Hasselquist 1992; Hasselquist 1998.
49 Węgrzyn et al. 2010.
50 Sejberg et al. 2000; Trnka and Prokop 2010.
51 Hasselquist 1998; Trnka and Prokop 2010.
52 Klaassen et al. 2014.
53 Strandberg et al. 2009.
54 Lok et al. 2015.
55 Sillett and Holmes 2002.
56 McGrady et al. 2015.
57 Brochet et al 2019.

CHAPTER 6

1 Jennings 2010.
2 Collar 2017c.
3 Bates 1936.
4 Goodwin 1986.
5 Madge and Kirwan 2018.
6 Birkhead 1991; Lee et al. 2003; Babbington 2016; Madge and Kirwan 2018.
7 Lee et al. 2016; Song et al. 2018.
8 Song et al. 2018.
9 Magnotti et al. 2016.
10 Zinkivskay et al. 2009.
11 Lee et al. 2011.
12 Prior et al. 2008.
13 Jennings 2010; Babbington 2016.
14 Yahya and Salamah 1996; Jennings 2010.
15 del Hoyo 2017b.
16 Buitron and Nuechterlein 1985; Healy and Krebs 1993; Feenders and Smulders 2011.
17 Yahya and Salamah 1996.
18 Babbington 2016.
19 Yahya and Salamah 1996; Babbington 2016.
20 Birkhead 1982; Birkhead et al. 1992.
21 Stanley 2002.
22 de Neve and Soler 2002; de Neve et al. 2014.
23 Soler et al. 2001.
24 Moreno-Rueda et al. 2007.
25 Hogstedt 1981; Husby 1986; Hochachka and Boag 1987.
26 Redondo and Castro 1992.
27 A. Alsuhaibany pers. obs.
28 Eden 1987.
29 Jennings et al. 2010.
30 J. Babbington, P. Roberts, pers. comm. 2019.
31 Bates 1936: 19.
32 Yahya and Salamah 1996: 13.
33 Jennings et al. 2010: 1.
34 Ebels 2003.
35 Babbington 2016.
36 Jennings et al. 2010; Babbington 2016.
37 Babbington 2016.
38 Jennings 2010; Hasanean & Almazroui 2015; Symes et al. 2015; Babbington 2016.
39 Eden 1987.
40 Frankham et al. 2014.
41 Jennings 2010.
42 del Hoyo et al. 2017b.
43 del Hoyo et al. 2017b.
44 Green et al. 1986.
45 Degen et al. 1984; Sánchez-García et al. 2012.
46 Jennings 2010.
47 Judas et al. 2006.
48 Munro et al. 2016.
49 Jennings 2010.
50 Jennings 2010.
51 Alvarez et al. 1986.
52 McGowan and Bonan 2017.
53 Binazzi et al. 2011; Sánchez-García et al. 2016.
54 Bortolotti et al. 2006.
55 Bortolotti et al. 2006; Alkon 2015.
56 Rands 1988.
57 Castell et al. 2001.
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59 del Hoyo et al. 2017b.
60 from Castell et al. 2001.
61 Mourão et al. 2010.
62 Green 1984; Casas et al. 2009.
63 BirdLife International 2016b.
64 Jennings 2010; Jennings et al. 2010.
65 BirdLife International 2016b.
66 Aliabadian et al. 2009.
67 Rands and Rands 1987; Jennings 2010.
68 Jennings 2010.
69 cf. Sánchez-García et al. 2012.
70 Jennings 2010; McGowan and Kirwan 2017.
71 Jennings 2010.
72 McGowan and Kirwan 2017.
73 Pérez-Rodríguez et al. 2006; Alkon 2015.
74 Alkon 2015.
75 Alonso et al. 2008.
76 McGowan and Kirwan 2017.
77 Lislevand et al. 2007.
78 McGraw and Hill 2000.
79 Olson and Owens 1998.
80 Blas et al. 2006.
81 Pérez-Rodríguez et al. 2006.
82 Pérez-Rodríguez and Viñuela 2008.
83 Mougeot et al. 2009.
84 Pérez-Rodríguez et al. 2006.
85 Pérez-Rodríguez et al. 2013.
86 Alonso-Alvarez et al. 2012.
87 McGowan and Kirwan 2017.
88 Castell et al. 2001.
89 McGowan and Kirwan 2017.
90 Jennings 2010.
91 Mourão et al. 2010.
92 Jennings 2010.
93 Jennings 2010.
94 BirdLife International 2016a.
95 Jennings 2010.
96 BirdLife International 2016a.
97 Symens et al. 1993.
98 Jennings 2010.
99 Semere et al. 2008.
100 Ogilvie-Grant and Forbes 1899.
101 Jennings 2010; Muzaffar 2013, 2015.
102 Jennings 2010.
103 King 2004.
104 Cook et al. 2017.
105 cf. Bairos-Novak et al., 2015.
106 Cook et al. 2017.
107 Muzaffar 2014; Cook et al. 2017.
108 Jennings 2010.
109 Jennings 2010; Cook et al. 2017.
110 Cook et al. 2017.
111 Jennings 2010.
112 Muzaffar et al. 2017.
113 Muzaffar 2015; Muzaffar et al. 2017.
114 King 2004; Jennings 2010.
115 Muzaffar et al. 2017.
116 Nettleship and Duffy 1995; Troynikov et al. 2013; Muzaffar et al. 2017.
117 Symens et al., 1993; Muzaffar et al., 2012; Muzaffar 2015.
118 Jennings 2010.
119 Orta et al. 2017.
120 Jennings 2010; Muzaffar et al., 2012; Muzaffar 2015.
121 Muzaffar et al. 2015.
122 Muzaffar et al., 2012.
123 Muzaffir 2015.
124 Gubiani et al., 2012.
125 Muzaffar et al., 2012.
126 Gubiani et al., 2012.
127 Muzaffar 2015.
128 Jennings 2010; Gubiani et al., 2012.
129 Muzaffar 2015.
130 Orta et al. 2017.
131 Orta et al. 2017.
132 Jennings 2010.
133 BirdLife International 2017e.
134 Symens et al. 1993; Aspinall 1995; Jennings 2010; BirdLife International 2017e.
135 Jennings 2010.
136 Symens et al. 1993.
137 Jennings 2010.
138 Symens and Suhaibani 1993; Symens et al. 1993, Jennings 2010; Muzaffar et al., 2013; BirdLife International 2017e; see also Al-Reasi et al. 2007; Agah et al. 2007; Skoric et al. 2012.
139 Muzaffar et al., 2013.
140 cf. Ryan et al., 2012.
141 Bates 1937.
142 Pons et al. 2013.
143 Jennings 2010; Holt et al. 2017a.
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154 Koch and Wagner 2002.
155 von Campenhausen and Wagner 2006.
156 Koch and Wagner 2002.
157 Takahashi 2010.
158 Geyer et al. 2013.
159 Bachmann and Wagner 2011; Chen et al. 2012.
160 Hsu et al. 2006.
161 Jennings 2010.
162 Tobias et al. 2016.
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165 Severinghaus 2000.
166 Jennings 2010.
167 Brown et al. 1987; Holt et al. 2017a.
168 Jennings 2010.
169 Sergio et al. 2009.
170 J. Babbington et al unpubl. data.
171 e.g., Koenig and Mumme 1987; Koenig et al. 2015; Ligon 1970; Williamson et al. 2016.
172 Jennings 2010; Winkler and Christie 2017.
173 Jennings 2010.
174 Winkler et al. 1996; Jennings 2010; Winkler and Christie 2017.
175 Winkler et al. 1996.
176 Zhou et al. 2009.
177 Everett 1987a; Jennings 2010.
178 Winkler et al. 1996.
179 Jennings 2010.
180 Winkler et al. 1996.
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187 Lee et al. 2014.
188 Gibson 2006.
189 Yoon et al. 2009, Yoon and Park 2011; Lee et al. 2014.
190 Jennings 2010.
191 Dodenhoff et al. 2001; Tremain et al. 2008.
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193 Jennings 2010.
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195 Winkler et al. 1996.
196 Yom Tov and Ar 1993.
197 Winkler et al. 1996; Jennings 2010.
198 Cockle et al. 2011.
199 Jennings 2010.
200 Brooks 1987; Jennings 2010.
201 Bairlein and Bonan 2017.
202 Brooks 1987.
203 Bairlein and Bonan 2017.
204 Brooks 1987.
205 Brooks 1987.
206 Jennings 2010.
207 Brooks 1987.
208 Peacock 2014.
209 Dalziell et al. 2015.
210 Brooks 1987.
211 Bairlein and Bonan 2017.
212 Jennings 2010.
213 Bairlein and Bonan 2017.
214 Castell et al. 2001.
215 Bairlein and Bonan 2017.
216 Bairlein and Bonan 2017.
217 Castell et al. 2001.
218 Bibby 1979.
219 Schaefer et al. 2004; Bairlein and Bonan 2017.
220 Castell et al. 2001.
221 Schaefer et al. 2004.
222 Schaefer et al. 2004.
223 Bairlein and Bonan 2017.
224 Bairlein and Bonan 2017.
225 Martin et al. 2000.
226 Schaefer et al. 2004.
227 Schaefer et al. 2005.

228 Bairlein and Bonan 2017.
229 Schaefer et al. 2004.
230 Bairlein and Bonan 2017.
231 Birdlife International 2017h.
232 Voelker et al. 2007.
233 Bowden 1987a; Porter et al. 1996; Jennings 2010.
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238 Cornwallis and Porter 1982.
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240 Phillips 1982.
241 Henty 1986.
242 Faivre et al. 2003a,b.
243 Collar 2017a.
244 Bowden 1987a; Castell et al. 2001.
245 Jennings 2010.
246 Collar 2017a.
247 Castell et al. 2001.
248 Collar 2017a.
249 Bowden 1987a; Castell et al. 2001; Jennings 2010.
250 Castell et al. 2001; Jennings 2010.
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260 Streif and Rasa 2001; Wysocki 2004.
261 Slagsvold 1982.
262 Møller 1990.
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266 Hatchwell et al. 1996; Weidinger 2001.
267 Götmark et al. 1995.
268 BirdLife International 2017i.
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270 BirdLife International 2017i.
271 Collar 2017b.
272 Jennings 2010.
273 Jennings 2010.
274 del Hoyo et al. 2017b.
275 Jennings 2010; Collar 2017b.
276 del Hoyo et al. 2017b.
277 Jennings 2010.
278 Jennings 2010.
279 Adams 2001.
280 Khoury and Boulad 2010.
281 Adams 2001.
282 McLeod 2014.
283 Jennings 2010.
284 Owens and Hartley 1998; Kraaijeveld 2003.
285 Jennings 2010.
286 Jennings 2010.
287 BirdLife International 2017c.
288 Jennings 2010.
289 del Hoyo and Collar 2017b.
290 Cheke and Mann 2017.
291 Jennings 2010.
292 Jennings 2010.
293 Cheke et al. 2017.
294 Al-Safadi and Kasparek 1995.
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312 Jennings 2010.
313 Owens and Hartley 1998; Dunn et al. 2001.
314 Riegert et al. 2014.
315 Riegert et al. 2014; Cheke et al. 2017.
316 Jennings 2010.
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326 Cheke et al. 2017.
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330 Palestine Sunbirds: Markman 2014; Purple Sunbirds: Sethi et al. 2010.
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362 Kirwan and Grieve 2007.
363 Collar et al. 2017.
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365 Jennings 2010.
366 Martins 1987; Jennings 2010.
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373 Lindström and Lundström 2001; Hõrak et al. 2003; Saks et al. 2003b; Aguilera and Amat 2007.
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402 Jennings 2010; Clement 2017a.
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422 Everett 1987b.
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426 Symes et al. 2015; Birdlife International 2016f.
427 For examples of extraordinary social behavior in little brown birds see work on Dunnocks: Davies 1992; Santos et al. 2015; Seychelles Warblers: Komdeur 1994; and female Superb Fairy-wrens: Double and Cockburn 2000.
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482 Jennings 2010.
483 Fry 2017.
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522 Castell et al. 2001.
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525 Tieleman et al. 2004; de Juana et al. 2017.
526 Tieleman et al. 2004; de Juana et al. 2017.
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528 Jennings 2010.
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531 Tieleman et al. 2004.
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GRACEFUL PRINIA

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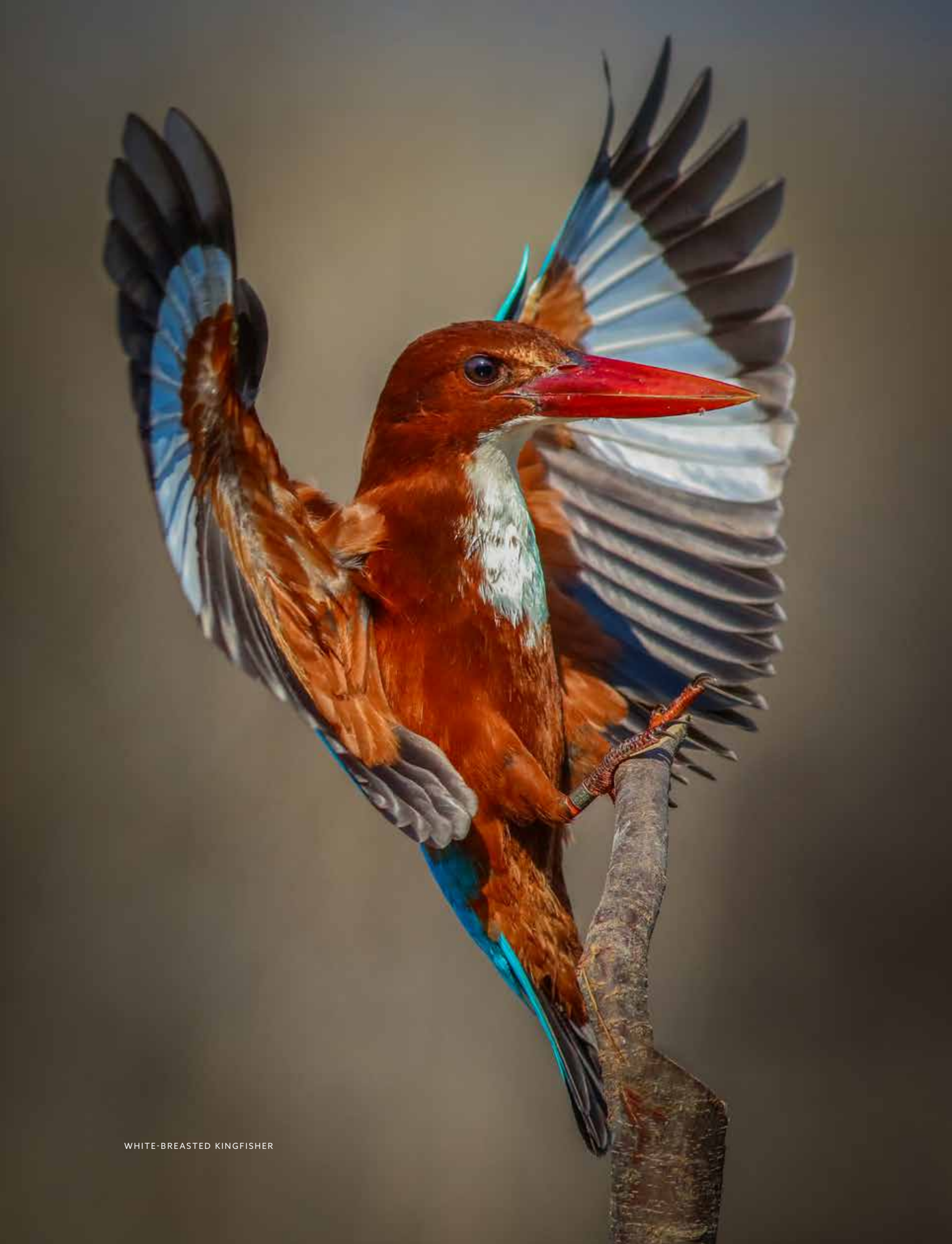

WHITE-BREASTED KINGFISHER