

Diurnal raptor migration, including wintering, on the Arabian peninsula, an overview

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The Arabian peninsula is an important part of a major migratory raptor flyway between Eurasia and Africa, and is itself an important winter destination. c28 migratory raptor species regularly migrate to or through countries in the peninsula, including the globally endangered Egyptian Vulture *Neophron percnopterus*, Steppe Eagle *Aquila nipalensis* and Saker Falcon *Falco cherrug*. Steppe Eagle and Steppe Buzzard *Buteo buteo vulpinus* are the most common migrants, and limited data suggest that the Caucasus and central Asia are the main summering areas of many of the migrants. Because of their size, location and the existence of migration bottlenecks, Saudi Arabia and Yemen are visited by more migrant raptors of more species than other countries on the peninsula. Although detailed data are lacking, it appears that the pattern of overwintering by some species, especially scavengers, may be changing. The most important threats to migrant raptors in the Arabian peninsula appear to be illegal shooting, poisoning and electrocution; trapping of large falcons may be currently unsustainable. Poor enforcement of existing laws and international agreements, and lack of data on numbers and ecology of migrating raptors in the peninsula undermine conservation efforts. The lack of data on the use of the Bab el Mandeb straits by migrant raptors is a particularly glaring knowledge gap. This paper summarizes the situation of migrating raptors in the Arabian peninsula on a national and regional level, providing a basic frame for filling in information gaps and identifying and prioritizing conservation challenges and opportunities.

INTRODUCTION

Many species of diurnal birds of prey (raptors) migrate, sometimes over very large distances (Newton 2008). The main driver of migration (seasonally and as an evolved behaviour) in birds is the seasonal change in food supply in breeding areas, with late summer declines triggering migration away from breeding areas, and springtime increases enabling their return. These changes in food supply are typically related to changes in environmental conditions including temperature, day length and rainfall (Alerstam 1990, Newton 2008). Although wintering habitats may be very different from summering habitats, they hold necessary food resources, which may also be very different from the food they eat in summer. As a consequence of wintering locations often being distant from breeding areas and breeding seasons being relatively short, many migratory birds spend more time away from their breeding areas (*ie* on outward and return migration and on wintering areas) than they do in them (Newton 2008). While the effect of migration and wintering enhances survival on a population level, the migratory component can be particularly hazardous for individual birds, especially for inexperienced juveniles (Newton 2006, 2008, Strandberg *et al* 2009, Klaassen *et al* 2014), and locations along migratory routes (especially bottlenecks) and on the wintering grounds can be focal points for persecution (*eg* Zalles & Bildstein 2000, van Maanan *et al* 2001).

Raptors that migrate fall into two general groups: those that soar and active fliers (Kerlinger 1989, Zalles & Bildstein 2000). While migrating, soaring birds (*eg* vultures, eagles, buzzards) seek out places where updraughts occur, and avoid crossing expanses of open water, active fliers (*eg* falcons, harriers), on the other hand, are not as sensitive to barriers of water or terrain. As a result of these different flight strategies and the geographic features that lie between breeding and wintering grounds, migrating raptors, especially soaring species, can be concentrated at 'bottlenecks', while in the absence of geographical features to constrain them, both types of migrants can migrate over a 'broad front'.

Amongst the c300 raptor species that occur worldwide, over 60% are migratory, most of which migrate from north temperate breeding areas to wintering areas that are more

southerly (Zalles & Bildstein 2000). Shirihai *et al* (2000) stated that 43 raptor species that breed in Eurasia migrate through the Middle East twice each year.

Human interest in raptor migration on the Arabian peninsula has a long history, especially because of falconry. Lewicka-Rajewska (1997) noted that depictions of falconry in Arabia, presumably using some birds caught on migration, date from as early as c550 CE. However, migration of raptors to and through the Arabian peninsula has, in recent years, been overshadowed in the ornithological community by the more famous migration bottlenecks in neighbouring countries (*eg* Suez in Egypt and Eilat or Kfar Qassem in Israel (Shirihai *et al* 2000)).

Within the peninsula probably the best known migration route runs along the Red sea coast, through western Saudi Arabia and Yemen, through the Tihamah, which is part of the Great rift valley flyway (Porter 2005, Shirihai *et al* 2000, Welch & Welch 1992). In autumn this route is used by only a proportion of the raptors flying south towards Africa out of Europe and Asia, with others crossing into Africa at Suez. Some of those that fly down the Saudi and Yemeni west coasts then cross the Red sea into Africa at the Bab el Mandeb straits; some stop along the way and spend the winter in the peninsula (Porter & Christiansen 1987, Welch & Welch 1988, 1991b, Buechley *et al* 2018b). Likewise, in spring, a portion of the migrants leaving Africa for Eurasian summering grounds cross the Bab el Mandeb into the Arabian peninsula, and head north along the Red sea coast (Welch & Welch 1991a, 1999). Professional trapping activities along the Red sea coast of Saudi Arabia and Yemen aimed at providing large falcons for falconry (Shobrak 2014, Binothman 2016) highlight the existence of transArabian peninsula raptor migration.

Migratory raptors face a wide variety of threats, which can vary along their migration routes. Globally, about two-thirds of migratory raptors are challenged by habitat loss, direct and indirect persecution, and the effects of environmental contamination (Zalles & Bildstein 2000). In the Arabian peninsula threats to migratory raptors include direct persecution (shooting, poisoning), and accidental poisoning/contamination at unregulated dump sites, oil ponds and agricultural sites (www.cms.int/raptors/en/page/agreement-text). All countries in the peninsula have laws that protect birds of prey, though the extent of protection varies, and some countries have joined regional, continental and global agreements and initiatives that include in their aims the protection of migratory raptors (BirdLife 2017a). However, overall, and in spite of any laws or agreements, enforcement is considered to be weak in the peninsula.

Much published work exists on raptor migration at locations just outside the Arabian peninsula, including Suez (*eg* Bijlsma 1983, 1987, Wimpfheimer *et al* 1983, Megalli & Hilgerloh 2013), and the migration hotspots of Israel (*eg* Shirihai & Christie 1992, Leshem & Yom Tov 1996, Yosef 1998), and Jordan (Zalles & Bildstein 2000). Publications that exist for the peninsula focus on counts made at the Bab el Mandeb and the Red sea coast of Yemen and Saudi Arabia (*eg* Welch & Welch 1991a, b, 1999, Zalles & Bildstein 2000), and a variety of short publications and records in national bird lists (*eg* Aspinall 1993, Eriksen & Victor 2013, KORC 2017).

This paper reviews the current status of raptors that migrate to and through the Arabian peninsula, drawing together published and unpublished information from each country to provide a regional overview. Because of the very nature of migrants, effective activities aimed at conserving them are likely those that are not constrained by national borders within the region, or at a larger scale. However, data on raptor numbers that use the peninsula during the non-breeding season, when they exist, are often hard to access. This paper aims to make available existing data, which can help identify important information gaps that need to be filled.

METHODS

The countries on the Arabian peninsula comprise Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates and Yemen. The species of interest were those that regularly migrate to or through the area, and these include non-resident and partial-migrant species that were classed as abundant, common, locally common or regular during the non-breeding season in the sources that were found. This review does not consider species that were classed as uncommon, rare or vagrants, except when doing so contributes to a holistic review of raptor migration in the study area, provides important information on species of particular conservation concern or helps identify nascent migration trends.

A list was compiled for each country of relevant species by searching books (eg Cramp & Simmons 1980, del Hoyo *et al* 1994, Zalles & Bildstein 2000, Ferguson-Lees & Christie 2005, Shirihai *et al* 2006, Porter & Aspinall 2010) and internet sources (eg BirdLife 2017a,b) for species' distributions and migratory routes. Lists were refined by searching hard copy and internet based regional and national bird lists (eg Eriksen & Victor 2013, KORC 2017, OSME 2017, Pedersen *et al* 2016) and atlases (eg Jennings 2010), and contacting individuals with specific knowledge of the status of raptors in these countries (see Acknowledgements).

To locate additional relevant publications that might improve this review, Web of Science (<http://apps.webofknowledge.com/>) and Google Scholar (<https://scholar.google.com/>) were searched, using a combination of key words (eg raptor migration, raptor wintering, Middle East, Arabia), and common and scientific names of the listed species. Because of its focus on birds in the Middle East, issues of *Sandgrouse* were examined for relevant information. Books in English with titles suggesting that raptor migration or wintering in the Arabian peninsula may have been reported were searched (eg Shirihai *et al* 2000, Bildstein 2006). The references listed in those publications were examined for information that had not been found in other ways. However, no claim is made to have found every relevant publication, and for various reasons (eg obsolescence or referring to vagrants) some of those found are not cited in this review. Finally, unpublished and difficult to find information on raptor migration and wintering in the Arabian peninsula was sought by contacting sources via social media and email.

This review reports mostly information at the species level, using names per Gill & Donsker (2017). Eurasian Honey Buzzard *Pernis apivorus* and Crested Honey Buzzard *P. ptilorhynchus* are recorded in all Arabian countries, and I have treated them as 'honey buzzard' *Pernis* because of difficulties in separating them in the field, and the potential for misidentification, especially in former years. Mostly European Honey Buzzards are found in the western Arabian peninsula as modest numbers migrate along the western coasts of Saudi Arabia and Yemen, especially during autumn. They cross into Africa via the Bab el Mandeb straits, and limited counts there suggest this passage may be underappreciated (Welch & Welch 1988). Crested Honey Buzzard occurs in fairly low, but increasing, numbers and has a more eastern distribution in the peninsula (Babbington & Campbell 2016).

Information on Black Kite *Milvus migrans* includes data from both the *migrans* and *lineatus* (Black-eared Kite) subspecies. Information on Common Buzzard *Buteo buteo* is most probably related entirely to *B. b. vulpinus* Steppe Buzzard. Terms used by published and internet sources to describe the status of migrants sometimes overlap—an individual species might be reported as "rare" by one source and "vagrant" by another. This review considers information from all sources and knowledgeable people with recent *in situ* experience to rationalize the differences.

Falconry, using large falcons (including Saker Falcon), is an important part of the cultural heritage of most countries in the peninsula. Wild captured migrant Saker Falcons

are popular with falconers, but there are concerns that trapping and modern falconry practices are contributing to the decline of this species in the wild. This situation has led to many publications on falconry, falcon harvest and falcon conservation, and stakeholders have developed a Global Action Plan for Saker Falcons (SakerGAP, Kovács *et al* 2014). For these reasons, special attention is paid to large falcons, especially Saker Falcon, in the discussion.

Though some of the migrants spend the non-breeding season south of the equator, findings are reported relative to boreal seasons: 'summering' areas are those used by raptors during the breeding season when they are not migrating (boreal summer, generally April–August), 'wintering' areas are used by raptors during the non-breeding season when they are not migrating (boreal winter, generally December–February),

RESULTS

Regional overview

An informed guess is that 3 million raptors pass through the region every autumn (D Alon, K Bildstein pers comms), then due to overwinter mortality a lower number migrate north through the region in spring. Figure 1 shows the apparent general flow of migrating raptors through the area in autumn, when they enter the peninsula at bottleneck locations and cross a broad migrating front. The main bottleneck locations in autumn for birds entering the Arabian peninsula are in northwest Saudi Arabia (crossing from Egypt or Jordan) and at the head of the Arabian/Persian gulf (hereafter Gulf) near Kuwait (Shirihai *et al* 2000). By definition, broad-front migrants arrive in the Arabian peninsula in autumn

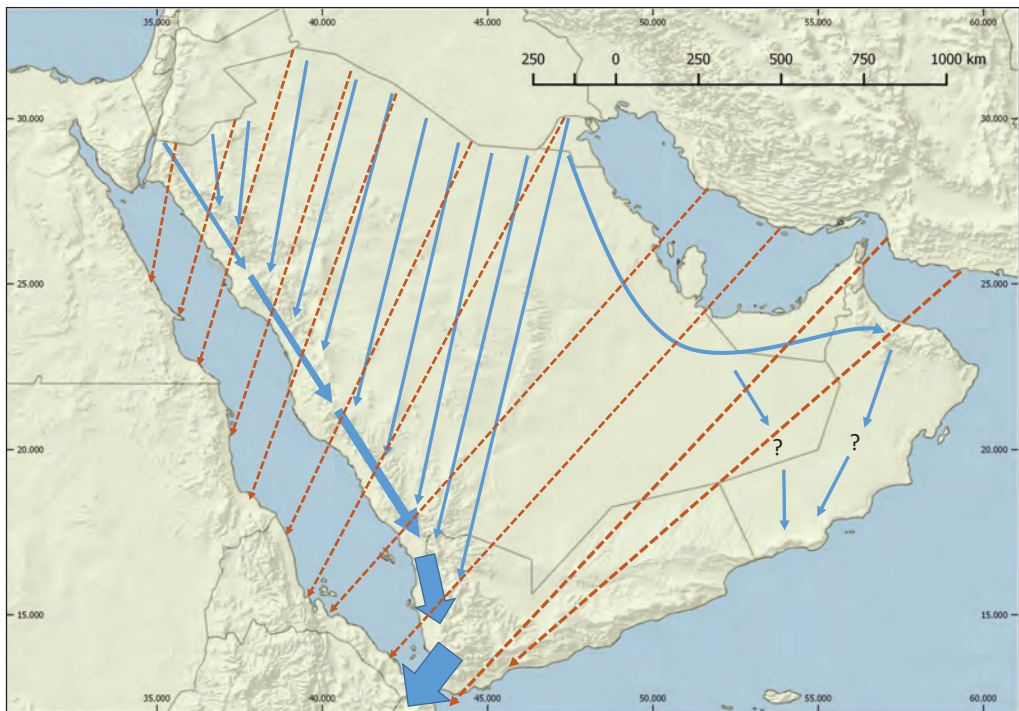


Figure 1. Apparent flow of migrant raptors through the Arabian peninsula during autumn (adapted from maps in Shirihai *et al* 2000, Zalles & Bildstein 2000, Bildstein 2006). The narrow parallel arrows illustrate a broad front migration rather than a series of well-defined parallel migration routes. Orange arrows = active flying species (ie falcons, harriers); blue arrows = soaring species (eg eagles, vultures, buzzards). The thickness of the arrow estimates the relative volume of migrants. Note: some migrants will not move through the peninsula, but will winter there.

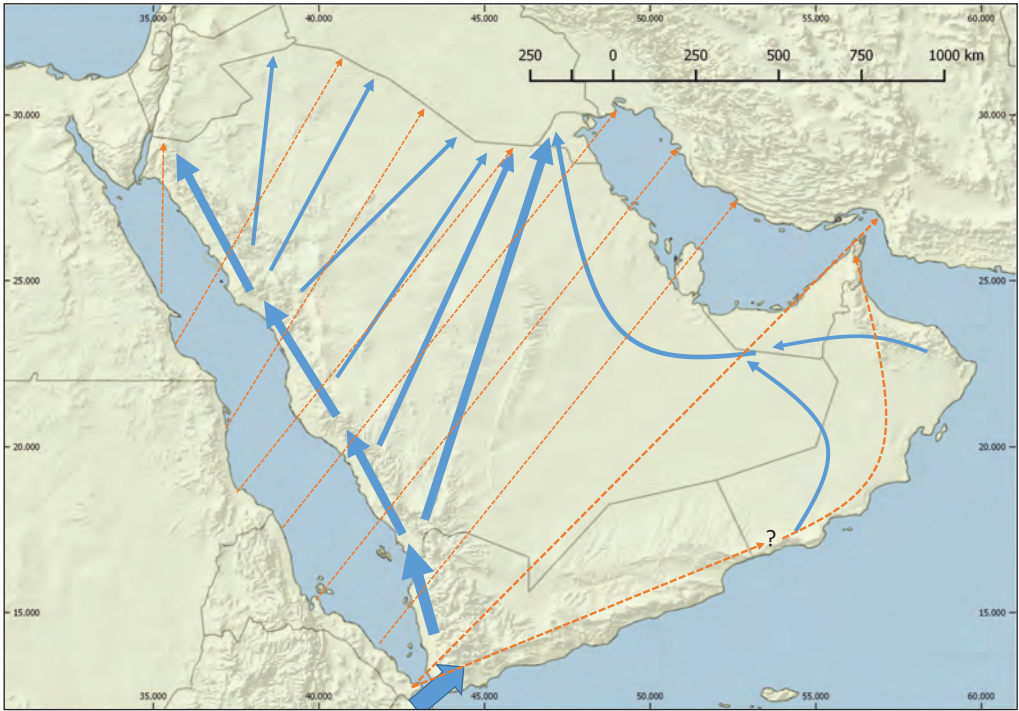


Figure 2. Apparent flow of migrant raptors through the Arabian peninsula during spring migration (adapted from maps in Shirihai *et al* 2000, Zalles & Bildstein 2000, Bildstein 2006). The narrow parallel arrows illustrate a broad front migration rather than a series of parallel well-defined migration routes. Orange arrows = active flying species (ie falcons, harriers); blue arrows = soaring species (eg eagles, vultures, buzzards). The thickness of the arrow estimates the relative volume of migrants. Note: some spring migrants will have wintered in the peninsula.

at various locations on the northern and eastern perimeters, having crossed land or sea to get there. Some proportion of arriving birds dwell in the peninsula for the winter, and are distributed across the peninsula, selecting preferred habitats and accessing food resources that enable them to survive the non-breeding season. Others pass through to Africa, with soaring birds (eg eagles and buzzards) mainly exiting the peninsula at the Bab el Mandeb straits between Yemen and Djibouti (Welch & Welch 1988), and active fliers (eg falcons and harriers) crossing the Red sea or gulf of Aden at any point (eg Limiñana *et al* 2014, Meyburg *et al* 2018).

In spring, many soaring migrant raptors enter the Arabian peninsula via the Bab el Mandeb straits, though more exit Africa via Suez at the northern end of the Red sea and therefore bypass the peninsula (Wimpfheimer *et al* 1983, Welch & Welch 1991, 1999, Shirihai *et al* 2000, Bildstein 2006, McGrady *et al* 2014). As with their southward journey and in contrast to soaring species, active fliers will cross the Red sea at any point on their way north (Figure 2). Birds that have spent their winter in the peninsula join the flow of migrants from Africa that pass through the peninsula heading northwards. The Amur Falcon *Falco amurensis* is something of a special case in this regard in that in autumn they do not pass through the peninsula, and in spring they appear to leave Africa from farther south (eg Somalia), and may only 'regularly' visit Yemen or Oman during their migration over the Indian ocean to India and on to breeding grounds in far eastern Asia (www.satellitetracking.eu/, Meyburg *et al* 2017).

Twenty-eight species of raptor migrate to or through one or more of the countries of the Arabian peninsula on a regular basis (Table 1). Autumn migration is stronger than

Table 1. Occurrence of migrant raptor species in countries on the Arabian peninsula. IUCN Status: EN=Endangered, VU=Vulnerable, NT=Near Threatened, LC=Least concern. Occurrence: A=Abundant; C=Common; LC=Locally common; Reg=Regular at low numbers; U=Uncommon; R=Rare; V=Vagrant; ND=No data/Not recorded; ?=unclear, for large falcons this is due to falconry escapes

	IUCN Status ¹	B ²	K ³	O ⁴	Q ⁵	SA ⁶	UAE ⁷	Y ⁸
Western Osprey <i>Pandion haliaetus</i>	LC	C	R	C	C	C	C	C
Egyptian Vulture <i>Neophron percnopterus</i>	EN	V	R	C	V	C	R	C
Honey Buzzard* <i>Pernis</i> spp.	LC	Reg	R	U	V	Reg	U	Reg
Griffon Vulture <i>Gyps fulvus</i>	LC	ND	R	U	ND	U	V	U
Cinereous Vulture <i>Aegyptius monachus</i>	NT	ND	R	V	ND	U	V	U
Short-toed Snake Eagle <i>Circaetus gallicus</i>	LC	U	U	C	R	U-R	U	R
Greater Spotted Eagle <i>Clanga clanga</i>	VU	Reg	C	A	R	U	LC	C
Booted Eagle <i>Aquila pennata</i>	LC	U	U	C	V	C-Reg	U	C
Steppe Eagle <i>Aquila nipalensis</i>	EN	U	C	A	V	A	R	A
Eastern Imperial Eagle <i>Aquila heliaca</i>	VU	ND	U	C	V	C	R	R
Levant Sparrowhawk <i>Accipiter brevipes</i>	LC	ND	R	ND	V	LC	ND	LC
Eurasian Sparrowhawk <i>Accipiter nisus</i>	LC	Reg	U	C	R	C-Reg	C	C
Western Marsh Harrier <i>Circus aeruginosus</i>	LC	C	R	A	C	C	A	C
Hen Harrier <i>Circus cyaneus</i>	LC	V	R	U	V	R	R	R
Pallid Harrier <i>Circus macrourus</i>	LC	Reg	C	C	C	C	C	C
Montagu's Harrier <i>Circus pygargus</i>	LC	Reg	U	C	R	U	U	U
Black Kite** <i>Milvus migrans</i>	LC	U	R	C	R	A	U	C-A
Long-legged Buzzard <i>Buteo rufinus</i>	LC	U	R	U	R	C	U	C
Common Buzzard*** <i>Buteo buteo</i>	LC	C-Reg	C	U	V	C	U	A
Lesser Kestrel <i>Falco naumanni</i>	LC	C	C	C	U	C	C	C
Common Kestrel <i>Falco tinnunculus</i>	LC	C-A	U	C-A	C	C-A	C	C-A
Amur Falcon <i>Falco amurensis</i>	LC	ND	V	U	ND	V	ND	R
Sooty Falcon <i>Falco concolor</i>	NT	R	V	LC	V	LC	U	U
Merlin <i>Falco columbarius</i>	LC	V	R	V	R	R	R	R
Eurasian Hobby <i>Falco subbuteo</i>	LC	Reg	U	C	R	R	U	U
Lanner Falcon <i>Falco biarmicus</i>	LC	ND	R	R	?	R	V	R
Saker Falcon <i>Falco cherrug</i>	EN	U	R	R-?	?	R	?	R
Peregrine Falcon <i>Falco peregrinus</i>	LC	Reg	R	C	?	C	Reg	C

¹ www.iucnredlist.org/, ² Bahrain, ³ Kuwait, ⁴ Oman, ⁵ Qatar, ⁶ Saudi Arabia, ⁷ United Arab Emirates, ⁸ Yemen

* *Pernis apivorus* and *P. ptilorhynchus* lumped due to difficulties in distinguishing the species. *P. apivorus* is more commonly seen in western Arabian peninsula and *P. ptilorhynchus* in eastern.

**Black Kite includes *Milvus m. migrans* and *M. m. lineatus*.

*** Nearly all Common Buzzards on the peninsula are *Buteo b. vulpinus*.

Sources: Aspinall (1993, 1994), Evans (1994), Jennings (2010), Porter & Aspinall (2010), Eriksen & Victor (2013), Pedersen et al (2016), Ferguson Lees & Christie 2005, Birdlife International (2017), Emirates Bird Record Committee (2017), Kuwait Ornithological Rarities Committee (2017), Ornithological Society of the Middle East (2017), Qatar Bird Records Committee (2017), MZ Al Islam, A Binothman, H King.

Table 2. Status of migrant raptors in the countries of the Arabian peninsula. R=Resident, P=Passage; W=Wintering; UV=Uncommon visitor; V=Vagrant; Escapes=Escapes from falconry; may be captive-bred and hybrid; B=Breeding; ND=No Data. Country abbreviations are as in Table 1.

	B	K	O	Q	SA	UAE	Y
Western Osprey <i>Pandion haliaetus</i>	R, P, W	P, W	R, P, W	R	R, P, W	R, P, W	R, P, W
Egyptian Vulture <i>Neophron percnopterus</i>	UV	P	R, P, W	V	R, P, W	R, P, W	R, P, W
honey buzzard* <i>Pernis</i>	P, W	P, W	P, W	V	P, W	P, W	P, W
Griffon Vulture <i>Gyps fulvus</i>	UV	P	P, W	ND	R, P, W	V	R, P, W
Cinereous vulture <i>Aegyptius monachus</i>	ND	P	V	ND	P, W	V	W
Short-toed Snake Eagle <i>Circaetus gallicus</i>	P, W	P, W	R, P, W	P, W	R, P, W	P, W	P, W
Greater Spotted Eagle <i>Clanga clanga</i>	P, W	P, W	P, W	UV	P, W	P, W	P, W
Booted Eagle <i>Aquila pennata</i>	P	P, W	P, W	V	P, W	P, W	P, W
Steppe Eagle <i>Aquila nipalensis</i>	P, W	P, W	P, W	V	P, W	P, W	P, W
Eastern Imperial Eagle <i>Aquila heliaca</i>	P, W	P, W	P, W	V	P, W	P, W	P, W
Levant Sparrowhawk <i>Accipiter brevipes</i>	ND	P, W	ND	V	P		P
Eurasian Sparrowhawk <i>Accipiter nisus</i>	P, W	P, W	P, W	UV, W	P, W	P, W	P, W
Western Marsh Harrier <i>Circus aeruginosus</i>	P, W	P, W	P, W	P, W	P, W	P, W	P, W
Hen Harrier <i>Circus cyaneus</i>	V	P, W	P, W	V	P, W	P, W	P, W
Pallid Harrier <i>Circus macrourus</i>	P	P, W	P, W	P, W	P, W	P, W	P, W
Montagu's Harrier <i>Circus pygargus</i>	P	P	P, W	P	P, W	P	P, W
Black Kite** <i>Milvus migrans</i>	P	P	P, W	V	R, P, W	P, W	R, P, W
Long-legged Buzzard <i>Buteo rufinus</i>	V	P, W	R, P, W	UV	R, P, W	R, P, W	R, P, W
Common Buzzard *** <i>Buteo buteo</i>	P, W	P	P, W	V	P, W	V	P, W
Lesser Kestrel <i>Falco naumanni</i>	P	P	P		P	P	P
Common Kestrel <i>Falco tinnunculus</i>	R, P	R, P, W	R, P, W		R, P, W	R, P, W	R, P, W
Amur Falcon <i>Falco amurensis</i>	ND	V	P	V	P	P	P
Sooty Falcon <i>Falco concolor</i>	B	V	B	V	B	B	B
Merlin <i>Falco columbarius</i>	V	P, W	V	UV, P, W	P, W	P, W	P, W
Eurasian Hobby <i>Falco subbuteo</i>	P	P	P	UV, P	P	P	P
Lanner Falcon <i>Falco biarmicus</i>	ND	W	P, W, Escapes	P, W, Escapes	R, P, W	P, W	R, P, W
Saker Falcon <i>Falco cherrug</i>	P	P, W, Escapes	P, W	P, W, Escapes	P, W	P, W, Escapes	P, W
Peregrine Falcon <i>Falco peregrinus</i>	P	R	P, W	P, W, Escapes	P, W	P, W, Escapes	P, W

* European Honey Buzzard *Pernis apivorus* and Crested Honey Buzzard *P. ptilorhynchus* are lumped together because of difficulties in distinguishing in the field.

** Black Kite includes *Milvus m. migrans* and *M. m. lineatus*.

*** Nearly all Common Buzzards on the peninsula are *Buteo b. vulpinus*.

Sources: Aspinall (1993, 1994), Evans (1994), Jennings (2010), Porter & Aspinall (2010), Eriksen & Victor (2013), Pedersen *et al* (2016), Ferguson Lees & Christie (2005), Birdlife International (2017), Emirates Bird Record Committee (2017), Kuwait Ornithological Rarities Committee (2017), Ornithological Society of the Middle East (2017), Qatar Bird Records Committee (2017), MZ Al Islam, A Binothman, H King.

spring migration, partially because of overwinter mortality (particularly of juveniles), but also because the funneling effects of land masses and bottlenecks direct more migrants through the peninsula during autumn than spring. Steppe Buzzard and Steppe Eagle *Aquila nipalensis* are the most numerous migrants in both spring and autumn. As one would expect, larger countries and countries where migration bottlenecks occur are visited by more individuals of more species.

Some species (eg Western Osprey *Pandion haliaetus*, Egyptian Vulture *Neophron percnopterus*) are partial migrants, and the resident population is augmented each autumn by birds arriving from farther north, but some pass through the region to winter farther south (Hake *et al* 2001). Some individuals of partial-migrant species that are also rare breeders may leave the peninsula southwards (eg Black Kite, Short-toed Eagle *Circaetus gallicus* (see Welch & Welch 1988)), but it is unclear if this is migration or just dispersal/nomadism across the narrow Bab el Mandeb gap (~30 km) between Arabia and Africa.

Evidence from ringing and colour-marking (eg Karyakin *et al* 2015, Poessel *et al* 2018), satellite radio tracking (eg Javed *et al* 2014, Sokolov *et al* 2016) and geolocators (Katzner *et al* 2016) links birds that winter or pass through the peninsula mostly with breeding areas in central and north central Asia. Some, but not all, birds for which data were available, showed fidelity to wintering areas on the peninsula (Gavashelishvili *et al* 2012, Javed *et al* 2014, Solokov *et al* 2016, <http://egyptianvultureoman.blogspot.co.at>). Marked birds that passed through the peninsula on their way south ultimately wintered in a variety of widely dispersed locations, mostly south of the Sahara (eg Jenkins & Stevenson 1997, Meyburg *et al* 2003, 2012, Dixon *et al* 2011, Terraube *et al* 2011), including along the upper reaches of the Nile drainage (Bildstein & Zalles 2000, Shirihai *et al* 2000, Bildstein 2006, Newton 2008), and sometimes as distant as South Africa (Meyburg *et al* 2018). Sooty Falcon *Falco concolor* is the only species that breeds in the peninsula, then migrates en masse to Madagascar and southwest Africa (Walter 1979, Jennings 2010, Javed *et al* 2012).

COUNTRY ACCOUNTS

Bahrain

Twelve species of migrating raptor regularly pass through or winter in Bahrain (Tables 1 and 2), mostly numbers are in the tens of individuals (H King pers comm). European Honey Buzzard, Crested Honey Buzzard, Eurasian Sparrowhawk *Accipiter nisus* and Eurasian Hobby *Falco subbuteo* are regularly observed (tens of individuals); *A. nisus* is seen year-round. Only a few species of conservation concern visit the country (eg Egyptian Vulture, Steppe Eagle, Saker Falcon *Falco cherrug*), but they do so only rarely or as vagrants. Sooty Falcon is a rare, regular breeder on the Hawar islands (IBA), whose population is declining (Kavanagh & King 2008). Lesser Kestrel *Falco naumanni* passage is notable, especially during spring. Aspinall (1993) stated that annually 500–1000 were captured in Bahrain for the caged bird market, but current reports are of < 750 arriving per year (H King pers comm). Less than 500 Common Kestrels *F. tinnunculus* are recorded annually, some overwinter. Both kestrel species are still regularly trapped, and can be found in the markets. Historically, Peregrine *Falco peregrinus* and Saker Falcons captured in Bahrain in autumn were prized by falconers because they had “demonstrated their strength” by crossing the Gulf (A Al Sharaf pers comm). Short-toed Eagle was once a fairly common passage migrant, but is now rare, perhaps because of loss of habitat to development (H King pers comm).

Kuwait

Five species of migrating raptor visit Kuwait on a regular basis (Tables 1 and 2), including endangered Egyptian Vulture (scarce) and Steppe Eagle (very common); endangered

Saker Falcon is considered rare (KORC 2017). Some IBAs list passage migrant raptors as key species, especially Egyptian Vulture, Steppe Eagle, Eastern Imperial Eagle *Aquila heliaca*, and Lesser Kestrel (Evans 1994); the Al Jahra pool nature reserve IBA is also a raptor migration watchsite (Zalles & Bildstein 2000). Kuwait's geographic position at the head of the Gulf means that some migrating soaring species may be concentrated. The highest daily count of Steppe Eagles is 2000 in September 2003 (KORC 2017). Local weather conditions during migration may affect whether migrants are seen in large numbers in Kuwait. Winter populations of all species of conservation concern are very small; a wing-tagged Eastern Imperial Eagle reared in Kazakhstan has been recorded (Poessel *et al* 2018). For most species, more migrants are seen in autumn than spring, Lesser Kestrels are an exception. In the mid 20th century flocks of 'tens of thousands' of Lesser Kestrels were recorded (KORC 2017), and flocks of over 1000 were not uncommon (Jennings 2010). Counts of these species are lower in recent years; the highest day count in recent years was of 117 in 2014 at Kabd reserve (KORC 2017). Seemingly only a few migrating large falcons are caught every year in Kuwait for falconry, but trapping sites in Saudi Arabia are nearby (Shobrak 2014) suggesting that some unknown number of migrant large falcons pass through; falconry escapees are sometimes seen (M Pope pers comm).

Oman

Seventeen species of migrating raptor regularly visit Oman during the non-breeding season (Tables 1 and 2) including endangered Egyptian Vultures, Steppe Eagles, and Saker Falcons (uncommon and including some escaped falconry birds). Steppe Eagle, Egyptian Vulture, Western Osprey, Greater Spotted Eagle *Clanga clanga*, Western Marsh Harriers *Circus aeruginosus* and Common Kestrel are the most numerous. It is not uncommon now to see hundreds of Egyptian Vultures, Steppe Eagles and other scavenging birds at some rubbish dumps during November–February (Eriksen & Victor 2013, Al Fazari & McGrady 2016, Environment Society of Oman unpublished data).

Eriksen & Victor (2013) list Booted Eagle *Aquila pennata*, Short-toed Eagle and Eurasian Hobby as common migrants and winter visitors. It is uncertain whether Bonelli's Eagles *Aquila fasciata* that are recorded include migrants (Eriksen & Victor (2013) or are only dispersing birds bred on the peninsula. Three IBAs (Evans 1994): Sun farms, Jazirat al Fahal and Al Qurm, are listed as raptor migration watchsites (Zalles & Bildstein 2000), the latter two because of breeding Sooty Falcons. A large part of the Sun farms IBA has been lost to development recently, and its status is in question.

In recent years, winter populations of Egyptian Vultures and Steppe Eagles appear to have increased (Al Fazari & McGrady 2016), though this impression may be affected by increased numbers of observers and waste management changes in the country resulting in fewer but larger gatherings of birds. Overall, potential increases in the resident population (Angelov *et al* 2013), the spatial overlap between resident and migrant populations, and the fact that young migrant Egyptian Vultures dwell in non-breeding areas for some years before returning to more northerly breeding areas (Oppel *et al* 2015, E Buechley unpubl data), add to the impression of a larger population in winter in recent years. Steppe Eagles and Eastern Imperial Eagles are predominant at rubbish dumps in the south (eg Raysut/Salalah), where large counts have been made (Eriksen & Victor 2013), sometimes exceeding 1000 individuals (N Al Kindi, B Meyburg pers comms).

Oman is a breeding stronghold for Sooty Falcon (Walter 1979, Gallo Orsi *et al* 2014, McGrady *et al* 2018). Autumn migration of Omani Sooty Falcons generally flows south into Yemen and Saudi Arabia, and then to Africa; information on spring migration is generally lacking (<http://sootyfalcon.blogspot.co.at/>).

Marked Eastern Imperial Eagles reared in Russia and Kazakhstan, and Steppe Eagles from Kazakhstan have wintered in Oman, feeding at rubbish dumps (Karyakin *et al* 2015, Bekmansurov *et al* 2016, Poessel *et al* 2018). Sub-adult Steppe Eagles radio tagged in winter 2016–2017 in Oman, migrated around the Gulf, and spent their summers in Kazakhstan and Russia (<https://egyptianvultureoman.blogspot.co.at/>); in 2017–2018 they wintered in Saudi Arabia (See account for Saudi Arabia), then returned to central Asia (<https://steppeeaglesoman.blogspot.co.at/>).

Oman is not along the main raptor migration routes between Eurasia and Africa that cross the peninsula (Figures 1 & 2). Steppe Buzzard, an abundant passage migrant in Saudi Arabia and Yemen that winters almost entirely in Africa, is only an uncommon (vagrant) winter visitor in Oman (Eriksen & Victor 2013). However, Eriksen & Victor (2013) list a number of species as passage migrants (*eg* Griffon Vulture) and winter visitors, which, given the geographic location of Oman, implies movement between Oman, Yemen, and Saudi Arabia.

The main migration of raptors out of Africa and through the Arabian peninsula in spring also seems to largely bypass Oman. However, observations in Oman of Lesser Kestrel are predominantly in the spring (Eriksen & Victor 2013) suggesting its autumn and spring migration routes differ, and that it might arrive in Oman in the spring via Yemen or Saudi Arabia (Figure 2). Amur Falcons also visit Oman mostly in spring, but numbers are low because the large majority of this species probably crosses between Africa and India over the sea (Meyburg *et al* 2017, www.satellitetracking.eu/inds/showtable).

The Musandam peninsula appears to be an important geographical feature that could facilitate the crossing of the Gulf between Iran and the Arabian peninsula by migrating raptors (Figures 1 and 2). There is little evidence for significant autumn raptor passage, though some information on spring migration exists. Aspinall (1993, 1994) documents spring migrating Lesser Kestrels (eagles and harriers also) heading north up the peninsula, mostly on the United Arab Emirates side of the border (see UAE account below).

Qatar

Four passage and wintering migratory raptor species regularly occur in Qatar (Table 1 and 2), including the endangered Steppe Eagle and Saker Falcon. It seems that some migrating Western Ospreys may winter in Qatar, but this is not confirmed. A wing-tagged Eastern Imperial Eagle reared in northern Kazakhstan was recorded in Qatar (Poessel *et al* 2018). The status of migrating large falcons (*ie* Saker and Peregrine Falcons), is unclear because of the high probability that records are of escaped falconry birds (QBRC 2017).

Saudi Arabia

Seventeen species of migratory raptor regularly visit Saudi Arabia, including the endangered Saker Falcon, Egyptian Vulture and Steppe Eagle (Tables 1 and 2). Some IBAs in Saudi Arabia list passage and wintering migrant raptors as key species, especially Saker Falcon and Egyptian Vulture (Evans 1994, MZ Al Islam pers comm). Al Hada and Wadi Jawwah are IBAs and raptor migration watchsites (Zalles & Bildstein 2000), especially in autumn. Porter (2005) names additional watchsites: Jabal Aja/Northern Ha'il and Wadi Rabigh springs. The main species that migrate through these sites (more in autumn) are Steppe Buzzard and Steppe Eagle (tens of thousands: Welch & Welch 1992), which are also the most numerous migrants that visit Saudi Arabia (Shirihai *et al* 2000, Zalles & Bildstein 2000). Though data are sparse, tracking of Eastern Imperial Eagles, Steppe Eagles, Cinereous Vultures *Aegypius monachus* and Egyptian Vultures (McGrady & Gavashelishvili 2006, Gavashelishvili *et al* 2012, Karyakin *et al* 2015, Buechley *et al* 2018a, b, <https://egyptianvultureoman.blogspot.co.at/>), and the location of falcon trapping sites

(Shobrak 2014) highlight that many raptors pass through central Saudi Arabia, and some winter there.

In autumn, soaring and active flying migrants enter Saudi Arabia in the far northwest, and are channeled south along the coastal corridor toward Yemen. They also enter the country across a broad front spanning the long northern border, and some active fliers enter from the east. The flow of broad-front migrants that soar is concentrated somewhat at the head of the Gulf (Kuwait), then farther south as they encounter the mountains of Saudi Arabia and eventually those of Yemen (Figure 1, Shirihai *et al* 2000, Zalles & Bildstein 2000).

For the majority of species, some individuals are passage birds, and others dwell over winter (*eg* some Eastern Imperial Eagles, Steppe Eagles, Pallid Harriers *Circus macrourus*, Long-legged Buzzards *Buteo rufinus* and Peregrine Falcons). Other species are entirely passage migrants (*eg* Lesser Kestrel, Levant Sparrowhawk *Accipiter brevipes*), or almost so (honey buzzards). Some species that spend the winter, do so in the presence of a resident population (*eg* Western Osprey, Egyptian Vulture, Common Kestrel), clouding the issue of whether a portion of the Saudi Arabian breeding population itself migrates. Saudi Arabia holds globally important numbers of breeding Sooty Falcons (Gaucher *et al* 1995, Gallo Orsi *et al* 2014); it is the only Saudi Arabian breeding raptor species whose entire population leaves the peninsula in the winter. Though uncommon, migrant Cinereous Vulture is most often observed in Saudi Arabia (Jennings 2010, Gavashelishvili *et al* 2012).

Tracking, ringing and colour marking suggest summering areas of migrants that winter in or pass through Saudi Arabia to be mostly from the Caucasus and central Asia (Meyburg *et al* 2003, 2012, McGrady & Gavashelishvili 2006, Gavashelishvili *et al* 2012, Javed *et al* 2017, RRRCN 2017, Buechley *et al* 2018a, b, Poessel *et al* 2018, <https://egyptianvultureoman.blogspot.co.at/>, MZ Al Islam, B Meyburg pers comms). At least some Peregrines that visit the kingdom are *ssp calidus* (Dixon *et al* 2012, Sokolov *et al* 2016), from the far north of Russia, and one adult male captured in Saudi Arabia in autumn migrated to Cape Town, South Africa (Jenkins & Stevenson 1997, Meyburg *et al* 2017). Although most migrants that fly through Israel in autumn enter Africa via Suez, some move down the Saudi Arabian coast toward the Bab el Mandeb straits, and some stop for the winter along the way. Tracked species that have migrated along this route include Egyptian Vultures (Buechley *et al* 2018a, b, including captive bred of parents of known Israeli provenance), Griffon Vultures *Gyps fulvus*, Lanner Falcons *Falco biarmicus*, and (vagrant) White-tailed Eagles *Haliaeetus albicilla* (O Hatzofe pers comm).

Spring migration in Saudi Arabia is mostly the reverse of that in autumn, with most soaring birds entering from Yemen after crossing the Bab el Mandeb straits from Africa. However, numbers are lower in spring because of overwinter mortality and because significant numbers migrate along the African coast of the Red sea to Suez as they move north (Shirihai *et al* 2000). In Saudi Arabia, some spring migrants are channeled along the west coast by the terrain (Welch & Welch 1992), but others migrate cross-country towards the northern border and north of the Gulf, heading for summering grounds in Eurasia (Figure 2). At least some Steppe Eagles that winter in Oman migrate through central and eastern Saudi Arabia to join the main flow of migrants heading north around the head of the Gulf (<https://egyptianvultureoman.blogspot.co.at/>).

Trapping sites for large falcons for falconry are distributed across Saudi Arabia, but clusters exist in the far northwest, in the north near the border with Kuwait and Iraq, and along the Red sea coast (Shobrak 2014, Binothman 2016). These reflect mostly the pattern of autumn large falcon migration, because traditionally most trapping was done at that time of year. See section on threats and conservation below.

United Arab Emirates

Eight passage and wintering migratory raptor species regularly occur in UAE (Tables 1 and 2). They include endangered Egyptian Vulture, Steppe Eagle and Saker Falcon, all in small numbers. Some IBAs in UAE list migrant raptors as key species, mostly on passage (Evans 1994). Located on the western slopes of the Hajar mountains near the border with Oman, Digdaga-Hamraniyah IBA is also a raptor migration watchsite (Zalles & Bildstein 2000). There, Lesser Kestrel is a key species, and is seen mostly in spring (EBRC 1994).

Like Bahrain and Qatar, UAE is off the main migratory route for most soaring raptors moving between Eurasia and Africa (Figures 1 and 2), and so relatively few raptors pass through, and populations of all species that winter there are small. However, the numbers of raptors, particularly Steppe Eagles, which winter in Oman suggest that some migrants may move unrecorded through UAE, perhaps inland.

Although it seems that Musandam as a terrain feature could facilitate crossing of the Straits of Hormuz by migrants, there is little evidence for large-scale movement between Iran and the Arabian peninsula via this route, either in autumn or spring. However, what migration does occur appears to be mostly along the western slopes of the mountains in UAE. Aspinall (1994) observed spring time movement by Lesser Kestrels, and eagles and harriers appear also to use this route (Aspinall 1993). See Oman account above. In the case of Lesser Kestrel the pattern of observations in UAE and neighbouring countries suggests that part of the spring migration flows towards Kuwait.

Because numbers of breeding Sooty Falcons are low in UAE (EBRC 1994, Shah *et al* 2008, Gallo Orsi *et al* 2014), few are seen on migration through any of the emirates. However, a juvenile Sooty Falcon was tracked via satellite, and it flew south through Saudi Arabia and western Yemen on its way to its wintering grounds (Javed *et al* 2011).

An immature Steppe Eagle that was captured in the UAE and tracked via satellite over two years, wintered in Yemen in one year and in Tanzania (Africa) in the other. As with other tagged eagles that use the region, it spent its summers in Kazakhstan (Javed *et al* 2014). A colour-marked Eastern Imperial Eagle that was reared in Russia was observed in UAE (RRRCN 2017).

Barton (2000) suggested a decline in the number of Saker Falcons being caught in UAE for falconry in the 1990s, but no decline in the number of Peregrine Falcons, information consistent with the conservation status of these two species (BirdLife International 2017b). The status of migrant large falcons in UAE is clouded by escaped falconry birds and trapping of wild birds. Some passage Peregrine Falcons are likely to be of *ssp calidus* that breeds in the far north of Russia (Dixon *et al* 2012, Sokolov *et al* 2016).

Yemen

Because the Bab el Mandeb is the most important migration bottleneck in the Arabian peninsula (Shirihai *et al* 2000, Zalles & Bildstein 2000) during spring (Welch & Welch 1988, 1991a, 1999) and autumn (Porter & Christiansen 1987, Welch & Welch 1991b), Yemen hosts a variety of species, and much of the volume of migrants moving between Eurasian summering areas and African wintering areas via the peninsula. Sixteen passage and wintering migratory raptor species regularly occur in Yemen (Tables 1 and 2). Some IBAs list passage and wintering migrant raptors as key species, especially endangered Saker Falcon, Steppe Eagle and Egyptian Vulture (Evans 1994). Al Kadan, Wadi Rijaf, Mafrq al Mukha, Bab el Madeb-Mawza and Ta'izz wadis are IBAs in Yemen that are also raptor migration watchsites (Zalles & Bildstein 2000).

The Bab el Mandeb is the focus of migration flow, both in spring and autumn (Figures 1 and 2). In western Yemen in autumn, south-bound, soaring raptors, especially Steppe Buzzard and Steppe Eagle that have already been concentrated by geographic features in

Saudi Arabia, fly between the Red sea coast and the uplands, along the Tihamah, towards the straits (Phillips 1982, Porter & Christiansen 1987, Welch & Welch 1991b, Buechley *et al* 2018a, b). Active fliers, like falcons, will also follow this path (Welch & Welch 1991b, Binothman 2016), but some of these will cross the Red sea at points north of the Bab el Mandeb. Some birds may also come across the mountains, but there is little evidence of significant autumn migration along the southern Yemen coast. The majority of Sooty Falcons from breeding areas in Oman and Bahrain and UAE (and some from Saudi Arabia) migrate through Yemen, but go unobserved; they migrate at different times than other species and they are rare.

Counts in autumn (of limited duration and some years ago) were of hundreds and sometimes thousands of raptors crossing the Bab el Mandeb straits per day (Cornwallis & Porter 1982, Porter & Christiansen 1987, Welch & Welch 1988, Kasperek 1997). Bildstein (2006) gives an annual value of > 240 000 individuals of 27 species. In spring Yemen receives migrants (mostly) that cross the Red sea at the Bab el Mandeb, and most belong to soaring species, especially Egyptian Vultures and Booted Eagles (Welch & Welch 1988, 1991a, 1998, McGrady *et al* 2014, Buechley *et al* 2018a, b). After crossing, the migration flows north in a pattern similar to autumn, but in reverse, and with the main movement travelling along the Tihamah. Autumn numbers are larger than spring numbers because many soaring migrants that cross the Red sea in autumn at the Bab el Mandeb, leave Africa via Suez in spring (Shirihai *et al* 2000, Bildstein 2006), and because of overwinter mortality.

As in other countries, some migrant raptors remain in Yemen for the winter, though details are lacking. Colour marked and satellite radio tracked Steppe Eagles and Eastern Imperial Eagles that have migrated to and through Yemen have summered in central Asia (eg Kazakhstan and southern Russia) (RRRCN 2017, Poessel *et al* 2018, O Hatzofe pers comm), Egyptian Vultures have summered in counties mostly between the Black and Caspian seas, including Turkey (Buechley *et al* 2018a, b).

DISCUSSION

The Middle East is used by large numbers of a wide variety of raptor species as they migrate between breeding grounds in Eurasia and non-breeding areas in Africa and the Arabian peninsula (Zalles & Bildstein 2000). About 28 species regularly visit the peninsula in appreciable numbers (taking into account the global rarity of some species), a variety of others are rare or vagrant visitors or residents whose movements appear to be mostly dispersal within super-regional breeding distributions (eg Bonelli's Eagle). Although data are lacking from the important bottleneck at the Bab el Mandeb straits, most seem to migrate (in both seasons) via the northern tip of the Red sea near Suez, Egypt; it is not known what minority proportion of the total number of migrants passing through the Middle East move through the Arabian peninsula. The composition of the migration in spring that passes near Suez is somewhat different than that in autumn as some birds do not follow the same path in both seasons (Shirihai *et al* 2000, Bildstein 2006).

Well-known concentration points, bottlenecks, of raptor migration exist just outside the Arabian peninsula. The Bab-el Mandeb straits bottleneck and the coastal plain of western Arabia (Tihamah) also concentrate migrating raptors in both spring and autumn, but are less well studied (Shirihai *et al* 2000, Buechley *et al* 2018b). Given its apparent importance, especially to globally endangered species, more data need to be collected on birds using the Bab-el-Mandeb crossing (Buechley *et al* 2018b), though remoteness and armed conflict are impediments to field work. Remoteness may provide some level of protection against persecution, but an armed human population has the ability to shoot many migrating birds (Nikolov *et al* 2016, Raine *et al* 2016), and makes it unsafe to do research.

Migrating raptors that use the Arabian peninsula seem to come mostly from breeding areas in central and northern Asia; tracked birds have come from areas that extend from the Baltic (c15°E, eg Osprey, Hake *et al* 2001) to central Asia (c65°E, eg Eastern Imperial Eagle Poessel *et al* 2018). Tracking data also suggest that the birds that fly through the peninsula come from areas generally farther east than those that migrate through Israel and Egypt (eg Meyburg 1995, Dixon *et al* 2011, Oppel *et al* 2015, Buechley *et al* 2018b, Poessel *et al* 2018). Migrant raptors spend the non-breeding period in the peninsula and in many widely dispersed areas in Africa, south of the Sahara and along the upper reaches of the Nile drainage (Bildstein & Zalles 2000, Shirihai *et al* 2000, Bildstein 2006, Newton 2008). Tracking studies of birds that use the Arabian peninsula are increasing, and will be particularly important in understanding resource use by raptors in the peninsula, timing of migration and survival. Information on location and connectivity of breeding areas and wintering areas of migrants will facilitate conservation strategies that span the annual range of raptor populations (Dixon *et al* 2012, Solokov *et al* 2016, Meyburg *et al* 2017, Buechley *et al* 2018b), which should make them more effective.

Although data are generally lacking, there seem to be changes occurring in the number of raptors that overwinter in the Arabian peninsula, and the presumption is that this is fueled mostly by birds stopping short of their traditional wintering areas in Africa because abundant food and perhaps new habitat now occurs in the peninsula. Such 'short-stopping', resulting in a changing winter distribution, is known for other raptors (eg Duncan 1996). The group of migrants that seems most affected is the scavengers (*Aquila* eagles, vultures and kites), which can feed on the increasing amount of available food resulting from a growing, more affluent human population. Some raptors that feed on live prey may also be more likely to winter in the peninsula than formerly eg honey buzzards, Common Kestrels, and harriers may find sufficient food in irrigated areas. In many parts of the Arabian peninsula, especially in the open desert, reptile and small mammal prey appear to be declining (S Ross, A Spalton pers comms), and this could affect the patterns of migration and distribution of raptors that prey upon them. However studies on a meaningful scale of mammals and reptiles important to raptors as prey are lacking.

Threats and conservation in the Arabian peninsula

Raptors face a variety of threats during migration through or wintering in the peninsula (www.cms.int/raptors/en/page/agreement-text). Fatalities and other effects are generally not reported or not collated, and so the numbers affected, their geographic distribution and the causes are not well understood. Despite this, the main threats are probably easy to deduce, and include shooting, collision with power infrastructure or electrocution, targeted and inadvertent poisoning (including oiling), and for large falcons, potentially unsustainable levels of trapping for falconry (see later).

BirdLife International is currently gathering data on illegal hunting of birds in the region, including raptors (www.birdlife.org/globally-threatened-bird-forums/2016/12/review-of-illegal-killing-of-birds-in-europe-the-arabian-peninsula-iraq-and-iran/). Postings on social media outlets confirm the existence of illegal shooting of raptors, but the scale of this problem is unknown. Illegal shooting almost certainly occurs in all countries in the study area, though Saudi Arabia and Yemen are considered to be where it is most common because of the volume of the migration, the national hunting cultures and the availability of firearms.

Electricity infrastructure (power lines, electricity poles and wind turbines) pose a global threat to birds. Raptor electrocutions have been recorded in Saudi Arabia (Shobrak 2012) and Oman (MJMcG unpublished data), and probably occur in other countries. In the case of Sakers, electrocutions on breeding grounds and along the flyway appear to be

affecting their numbers on migration, and may currently be the most important threat to that endangered species (Kovács *et al* 2014, Dixon *et al* 2016).

Migratory raptors in the Arabian peninsula probably suffer more from inadvertent rather than targeted poisoning. Inadvertent poisoning includes oiling at waste and evaporation pits at drilling and pumping operations and at associated water recovery stations. Poor municipal waste management practices can result in toxic material being consumed by migrating birds of prey, especially species that scavenge. The Gulf Cooperation Council countries (all the Arabian peninsula countries except Yemen) consistently rank among the top 10% of countries in the world in terms of per capita waste production (Ouda *et al* 2017). It is estimated that c120 million tonnes of waste are produced annually in the region, about 4% of which is organic waste (Ouda *et al* 2017), including food that scavengers could eat. Generally speaking, the countries of the region have been updating waste management practices, which should reduce this threat (though Yemen may lag behind in this). Improvements in waste management aside, the increasing volume of all waste due to a rapidly growing, more affluent, human population, probably means that the volume of available toxic waste is also increasing. Despite improvements in government-managed waste disposal, illegal dumping still occurs, and can be dangerous to scavenging raptors. As with illegal hunting, little is known about the severity of this problem.

The other side of better waste management is that it could reduce the amount of food available to scavengers and change its distribution in the environment. In Oman the updating of waste management is aiming to close over 300 small, sometimes poorly managed, dump sites, and create 12 large engineered landfills (www.beah.om/). Because historical data on numbers and distribution of scavenging raptors is generally lacking, assessing any changes is difficult. Some large engineered landfills in Oman attract large numbers of migratory scavenging raptors (Eriksen & Victor 2013, Al Fazari & McGrady 2016), but it is unknown whether total numbers have changed.

Large falcons and falconry

Migratory (Saker and Peregrine) large falcons are captured in the Arabian peninsula to supply the regional falconry market (non-migratory Lanner *Falco biarmicus* and Laggar *F. jurgar* Falcons are also trapped). Saker is of special interest because it is a species preferred by falconers (especially those hunting larger prey), a valuable target for trappers, and is seen to be more endangered than other falcon species in the peninsula (Kovács *et al* 2014).

While falconry is traditional in the Arabian peninsula, falconry practice has many modern components (*eg* overwintering of captive falcons, telemetry, captive breeding, use of hybrid falcons), and the issues around the conservation and sustainable use of large falcons are complex and interrelated. The two factors in the peninsula that most affect migrant falcons are the market that exists for wild-captured large falcons, and trapping activity itself.

Trapping activities for large falcons occur in all Arabian peninsula countries (Barton 2000, Shobrak 2014, Binothman 2016, MZ Al Islam, A Al Sharaf pers comms), except perhaps Oman. Information from Binothman (2016) and in the popular press (*eg* <http://timesofoman.com/article/43667/Oman/Royal-Oman-Police-foil-falcon-smuggling-attempt>) indicates that components of the trade in illegally-taken falcons occurs in all countries of the peninsula. Regionally, Saudi Arabia and Yemen are where most falcons are caught, reflecting their size and location relative to the main migration flow. In recent years a minimum of c200–250 large migratory falcons (70–80% Peregrine, 20–30% Saker) have been trapped in Saudi Arabia, mostly at three locations (Shobrak 2014). Also, Binothman (2016) reports that a minimum of 624 large falcons were trapped in 2014 in the Gulf

countries and 326 were trapped in Yemen. It seems that the level of global (in breeding and non-breeding areas) harvest is unsustainable for the Saker Falcon, though some stakeholders feel the harvest in the Arabian peninsula is rather unimportant (Kovács *et al* 2014). While other threats, like electrocution (especially on the breeding grounds), may be having a bigger impact on the population (Dixon *et al* 2013), it is important to view harvest of migrants as an additive loss of birds in the wild (Kovács *et al* 2014). Though actual data on the populations of Peregrines that visit the peninsula are lacking, global populations have recovered since historic lows caused by organochlorine contaminants (Ratcliffe 2000), and such a trend would be suspected for the population that migrate through the peninsula. Thus, over-harvest is, at present, likely to be less of a threat to Peregrines than to Sakers.

Despite reports of fewer large falcons in the wild (Binothman 2016, Meyburg *et al* 2017) and captive-reared falcons becoming more available, increased demand from a growing falconry community has resulted in higher prices being paid for wild falcons, more trappers using better techniques to catch more falcons each year, and an increased effort to trap in spring (Shobrak 2014, Binothman 2016). While some large falcons trapped or captive bred in the peninsula escape and become breeders (Sokolov *et al* 2016), it is not known whether this is having a positive effect on the wild population.

It is of particular importance that one remembers that these are migrant birds, and these and other threats occur on breeding grounds and non-breeding areas away from the Arabian peninsula and contribute to the continued endangerment of some species, and a changing picture of the migrants that use the peninsula. Successful conservation, therefore, will likely be planned to address threats across the annual range of these species, and seek to build consensus amongst stakeholders, an approach exemplified by the Saker Global Action Plan (Kovács *et al* 2014) and the Vulture Multi-Species Action Plan (Botha *et al* 2017). However, a current barrier to successful conservation is the lack of data and active fieldwork in the peninsula. A case in point is the Lesser Kestrel, which has seen its global status improve from Vulnerable to Least Concern (BirdLife International 2017b) at the same time as numbers of migrants seen in the Arabian peninsula have gone from thousands (Jennings 2010) or even 'tens of thousands' (KORC 2017), to hundreds (eg H King pers comm). Such an enigmatic situation could mask important conservation challenges and undermine population stability, a main goal of conservation efforts.

All countries on the peninsula have laws that regulate hunting and provide some legal protection for wildlife including birds, but those laws vary greatly between countries (BirdLife International 2017a), and their enforcement is generally considered to be weak (Kovács *et al* 2014, Binothman 2016, BirdLife International 2017a). Regional, continental and global agreements and initiatives that focus on raptors (eg CMS Raptors MOU (www.cms.int/raptors/en/legalinstrument/birds-prey-raptors), birds (eg BirdLife International's Soaring Birds Project (<http://migratorysoaringbirds.undp.birdlife.org/>)) or include migratory raptors (eg Convention on the Conservation of Wildlife and Natural Habitats in the Countries of the Gulf Cooperation Council (GCC) Annex III www.gcc-sg.org/en-us/CognitiveSources/DigitalLibrary/Lists/DigitalLibrary/Forests%20pastures%20and%20wildwild/1274593978.pdf; CMS Resolution on the SakerGAP www.cms.int/sites/default/files/document/cms_cop12_res.11.18%28rev.cop12%29_e.pdf). exist, but not all countries in the peninsula are signatories (BirdLife International 2017a, www.cms.int/raptors/en/). The Raptors MOU in particular is an effort that targets the threats to raptors that visit the region as migrants, and specific initiatives under that agreement (*ie* the SakerGAP (Kovács *et al* 2014) or the Vulture Multi-species Action Plan (Botha *et al* 2017)) attempt to define threats, devise solutions, and assemble the resources needed to enact those solutions.

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