

Distribution, diet and winter ecology of the Imperial Eagle *Aquila heliaca* in Jordan

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> Abstract

The present study is the first attempt to investigate the diet, seasonality and distribution of the globally vulnerable Imperial Eagle *Aquila heliaca* in a wintering habitat in Jordan. There was a temporal pattern of observations, with nearly all observations in the northwestern part of the country occurring in late December or January. The main wintering period for Imperial Eagles occurs in January and February where (84.3%) of observations were recorded, peaking in January. Adults predominated, followed by immature birds, with sub-adults being least common. Diet includes 14 identified species of mammals, birds and reptiles. Large domestic animals, most likely consumed as carrion, predominated the food composition of wintering eagles and formed 53.7 % of analyzed food items, followed by presumably live-caught birds (26%) and small and medium sized mammals (19.7%) and reptiles (0.6%) respectively. Trapping was the major threat affecting the Imperial Eagle in its wintering habitat in the eastern desert.

> Key words

Imperial Eagle, diet, ecology, Jordan.

Introduction

Despite the huge range of the Imperial Eagle *Aquila heliaca*, its small global population has declined significantly in recent years; these populations are likely to undergo continuing declines, primarily as a result of habitat loss and degradation, adult mortality through persecution and collision with powerlines, nest robbing and prey depletion (BIRDLIFE INTERNATIONAL, 2010), hence, it is classified as globally vulnerable (IUCN, 2010).

The Imperial Eagle is a large generalist predator whose geographic range extends from Western Europe into Central Asia, northwestern China and Siberia. The forest-steppe habitat it occupies during breeding season reaches from the southern edge of Eurasia's deciduous forest and taiga to the northern edge of the great Asian

deserts (STEPANYAN, 1990; SNOW & PERRINS, 1998). In the Western Palaearctic region of its distribution, it is estimated that the breeding population is about 1400 breeding pairs (MEBS & SCHMIDT, 2006; HORVÁTH *et al.*, 2002). On passage and in winter, birds are found in the Middle East, East Africa south to Tanzania, the Arabian Peninsula, the Indian subcontinent and South and East Asia (BIRDLIFE INTERNATIONAL, 2010).

Because of the threats it faces, Imperial Eagles are well studied on their breeding ground and conservation efforts are in place in those areas (GALUSHIN & BELIK, 1999; RUDNICK *et al.*, 2005). However, there is a deficiency in information about their diet, distribution, and threats in wintering areas, especially in the Middle East. The lack of knowledge of the winter ecology of

this species has been noted, especially in the eastern part of its range, where isolated populations appear to be declining rapidly (RYABTSEV & KATZNER, 2007).

As medium to long-distance migrant, Imperial Eagles require both winter and summer range protection and the long-term survival of the species therefore depends in part on sufficient understanding and mitigation of the threats it faces throughout the year. In Jordan, Imperial Eagles are a regular and significant winter visitor in suitable habitats throughout most of the country, making this an important place for survey and study of the winter ecology of this species (ANDREWS, 1995).

This study was designed to identify the ecological characteristics of Imperial Eagles wintering in the Jordanian Interior Desert. We focused on aspects of the temporal and spatial distribution of the species and its diet during winter, ultimately to document information on the species wintering ecology, status and behaviour.

Distribution of Imperial Eagles in the Middle East and Jordan

Imperial Eagles breed in Turkey, northwestern Iran and Cyprus; birds in these populations are partial migrants. Elsewhere throughout the region, the species occurs widely on passage and in winter. The migrant/wintering population has been estimated at 500–1,000 birds between October and March (CRAMP *et al.*, 1980; HEREDIA, 1996; SHIRIHAI, 1996; SNOW & PERRINS, 1998; FERGUSSON-LEES & CHRISTIE, 2001), however, an estimate of over 4000 wintering birds was made by JENNINGS (2009) with at least 63 individuals observed during February. Birds from Russia are known to winter in Saudi Arabia (HEREDIA, 1996), and birds from Kazakhstan winter throughout Iran and as far south as Oman (BRAGIN & KATZNER, 2004). The highest regional passage migration was seen at Eilat, adjacent to Aqaba, where up to 95 Imperial Eagles have been recorded in a single spring season (CRAMP *et al.*, 1980). In Jordan, Imperial Eagles appear as winter residents and as migrants. The majority of wintering birds are found in a wide area of eastern desert around Azraq (Fig. 1) and east to the Iraqi border during mid November to early March. Other areas also hold small numbers of wintering birds mostly of sporadic records and local reports (ANDREWS, 1995; ANDREWS *et al.*, 1999). Significant numbers of Imperial Eagles migrate through Jordan, migration is heaviest during south-bound movements in autumn; 29 migrating Imperial Eagles were observed at Wadi Rum during autumn 2000 (RSCN, 2000). Figure 1 shows the previous records of imperial eagle in Jordan.

Materials and Methods

Study area

Winter surveys targeted the Jordanian eastern marginal desert and semi desert lands known as 'The Badia', which makes up the eastern three quarters of the country (Fig. 1). This desert ecosystem is contiguous with the Arabian deserts of Syria, Iraq and Saudi Arabia and part of the Saharo-Arabian biogeographical zone. It is a gently undulating plateau with an elevation of 500–900 m asl and generally low annual precipitation ranging from 50–100 mm. The combination of this precipitation regime and poor soil quality results in sparse vegetation, except in wetland areas. In spite of the low vegetative cover, the Badia is the most heavily used rangeland in Jordan and the area has suffered from overgrazing (AL-EISAWI, 1996; BUDAIERI, 2000).

The Badia is composed of three general habitat types (AL-EISAWI, 1996). Hammada, Harrah and Qa'a. Hammada is a flint or limestone desert plain dominated by low shrubs, especially halophytic Chenopodiaceae such as *Seidlitzia rosmarinus*. Other associated vegetation includes annual herbs and succulent perennials, mixed with steppe/grassland vegetation to the west. Harrah, also called pebble Hammada, is composed of basaltic plains covered by volcanic rocks and scrubs. Vegetation in Harrah is dominated by other Chenopods, including Mediterranean saltwort *Salsola vermiculata* and *Halogeton alopecuroides*. Qa'a is dominated by mudflats; mesic depressions of accumulated soil deposits at the bottom of closed drainage basins. The borders of these habitats are populated by a variety of salt- and freshwater vegetation types, including *Capparis ovata*, *Nitraria retusa*, and *Suaeda* spp.

Spatial and temporal distribution of eagles

During winter 2006/7, observations of wintering Imperial Eagles in the Badia region were used to map the spatial distribution and to define the wintering dynamics of this population. To gather the spatial and temporal data, we counted birds for four days each month, from October to March. The 24 observation days were spaced at regular intervals throughout each month. On observation days, at least one observer drove regular routes along the major highways that cross the Badia, at known eagle roost sites and at other potential areas deemed to have a high probability for

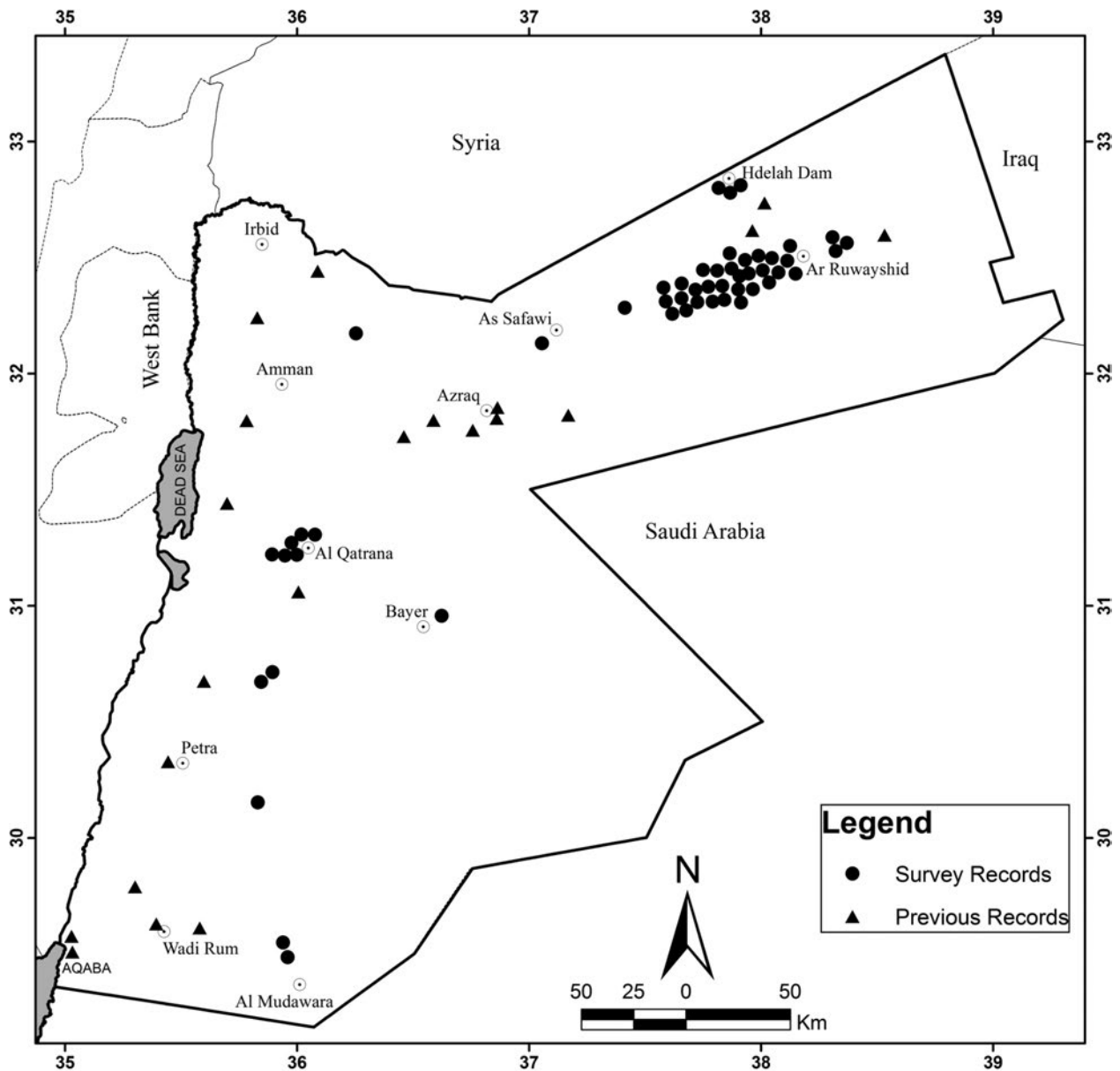


Fig. 1. Distribution map of wintering Imperial Eagle (*Aquila heliaca*) survey observations (Previous records include 21 localities/site comprising 39 records (17 wintering records, 9 passage migration records, 13 uncertain status "winter/passage" records). All previous records from the eastern mountains and between Aqaba and Wadi Rum are for migrant birds. For example, 29 passed over Wadi Rum during autumn, 2000, with no evidence of wintering birds there).

supporting eagles. Known sites were selected according to published literature and to unpublished records at the Royal Society for the Conservation of Nature (RSCN), Jordan. Observations were made in the early morning or late afternoon when birds were most likely to be at roosts. When eagles were observed, whether perching or flying, their geographic locations were taken by GPS as close as possible to the site where the bird was observed. Birds were aged according to their plumage (FORSMAN, 2003) and categorized into three age classes: Immature plumage (1–4 calendar year spring), subadult plumage (2 cy autumn – 7 cy spring) and adult plumage (7 cy autumn onward).

Winter diet of eagles

To investigate the diet of wintering Imperial Eagles, we collected pellets from known roosting sites at the largest locality in the eastern desert (span +120 km long) between As Safawi and the Iraqi border (Fig. 1). The bulk of these sites were electric pylons where eagles were observed perching for long periods. To ensure that dietary samples were from Imperial Eagles and not other species, pellets were not collected at communal roosting sites where other species of eagles had been frequently observed. Uneaten food remains were

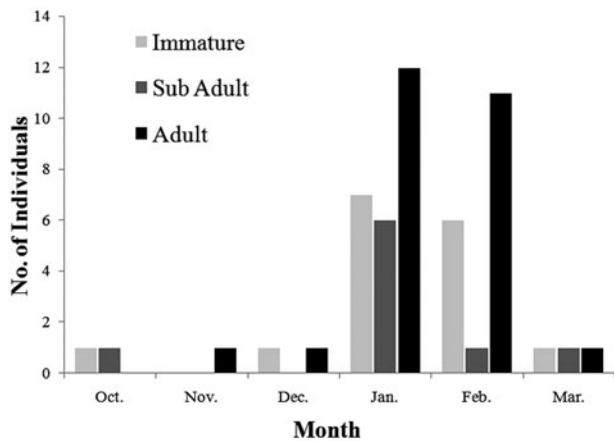


Fig. 2. Age structure and timing of observations of Imperial Eagles (*Aquila heliaca*) wintering in Jordan in 2006–2007.



Fig. 3. Adult Imperial Eagles on power pylons.



Fig. 4. Immature Imperial Eagle in Hammada/steppe habitat.

not sampled and analyzed, but noted when accompanied by eagle pellets to minimize confusion with other predators feeding remains.

Collected pellets were soaked in hot water for 15 minutes to soften the contents and to facilitate separating key identifiable materials. After soaking, each pellet was then placed in a Petri dish and the contents separated with tweezers. All bones, fur, feathers, beaks, claws, teeth and other identifiable materials were set aside for analysis and identification. Samples were identified to the lowest taxonomic level possible using

published diagnostic criteria and reference materials (BROWN *et al.*, 1987, HARRISON & BATES, 1990).

Results

Spatial and temporal distribution

During a single winter survey (October 2006 to March 2007), a total of 51 sightings of wintering Imperial Eagles were recorded in the Badia region, of these observations, adults predominated with 26 sighting (51%), followed by 16 immature birds (31.4%) and nine subadults (17.6%). The majority of Imperial Eagles were recorded in the eastern part of the Badia (Fig. 1), east of As Safawi area to Ar Ruwayshid (72%; $n = 37$). Other observations were spatially scattered, with one small cluster at the Al Qatrana area in the south (12%; $n = 6$).

The winter cycle of Imperial Eagles in Jordan spanned a period from the beginning of October to early March (Fig. 2). The peak wintering period for Imperial Eagles occurs in January and February where 43 sightings (84.3%) were recorded, with 25 birds seen in January, during which seven individuals (4 immature, 2 subadults and 1 adult) were recorded in the same location on power pylons, presumably were roosting near feeding carcass provided the abundance of suitable roosting sites (Fig. 3). Because of the low number of observations early and late in the season, it was not possible to detect age-related trends in eagle's use of these habitats. However, there was a temporal pattern of observations, with nearly all observations in the west-central part of the country occurring in late December or January.

Fifty-seven percent of the observations were recorded in the basalt Harrah habitat, while 43% were recorded in Hammada/steppe habitat (Fig. 4), where both types of habitats are interlocked by seasonal tributaries and wadis draining to mudflats or water bodies; 16% of observations were near Al Qatrana and Hdelah Dam. Most records were for birds perching on electric pylons along the highway roads away from inhabited areas. The rest were seen flying, perching on high grounds or in some occasions feeding on animal carcasses.

Local movement during winter in the Badia is most likely to occur; mainly for foraging and according to weather/flood conditions. During our survey, birds were very sensitive to any form of disturbance and flew away when approached from a distance, their

movement was very localized; mainly from one pylon tower to another.

Winter Diet

A total of 160 regurgitated Imperial Eagles pellets were collected and analyzed. We identified a minimum of 177 food items in those pellets, belonging to three classes; Aves, Mammalia and Reptilia. We were able to identify 14 types of prey to the species level (Tab. 1). Domestic animals, most likely consumed as carrion, predominated the food composition of wintering eagles and formed 53.7% of analyzed food items, followed by presumably live-caught birds (26%), mammals (19.7%) and reptiles (0.6%) respectively.

Discussion

Wintering habitat and distribution

Imperial eagles used the Badia region primarily from October to March in a manner consistent with historical records of wintering behavior by this species (see introduction), nonetheless, no birds were seen around Azraq; an area previously supporting up to 20 wintering birds (ANDREWS, 1995). In particular, the majority of the observations was in the northeast region and was predominated by adults, both trends have been reported in previous unpublished observations. The fact that adults dominate this region (51% adults, 49% non-adults) suggests that adults may be wintering closer to their breeding ranges in Eurasia (ERIKSEN & ERIKSEN, 1996), this could be supported by observations of pre-adult birds near Al Mudawara south of Jordan. LOBLEY (2007) also suggested wintering of adult eagles closer to their breeding ranges in the Arabian Peninsula. However, in Palestine, SHIRIHAI (1996) stated that age composition of wintering imperial eagles averages 28% adults and the rest were non-adults, mainly 1st winter birds.

We also observed no consistent pattern of habitat use by these eagles; the distribution of these birds, rather than being driven by habitat parameters we measured, is instead driven by the availability of suitable food and minimization of disturbance. In contrast, in the closest wintering area to the west, SHIRIHAI (1996) reported wintering in Mediterranean to semi desert cli-

Table 1. Composition of regurgitated pellets produced by wintering Imperial Eagles (*Aquila heliaca*) in the Badia region during winter 2006/7 (n = 160 pellet).

| Class | Order | Species | No. of prey items | ≈ % prey items |
|------------------|------------------|---------------------------------------|-------------------|----------------|
| Aves | Falconiformes | <i>Falco columbarius</i> | 2 | 1.1 |
| | | <i>Falco tinnunculus</i> | 7 | 4.0 |
| | Passeriformes | <i>Corvus ruficollis</i> | 1 | 0.6 |
| | | <i>Alaudidae</i> sp. | 6 | 3.4 |
| | | <i>Oenanthe</i> sp. | 1 | 0.6 |
| | | Unidentified | 6 | 3.4 |
| | Pteroclidiformes | <i>Pterocles alchata</i> | 1 | 0.6 |
| | Galliformes | <i>Gallus gallus</i> | 1 | 0.6 |
| | Strigiformes | <i>Athene noctua</i> | 1 | 0.6 |
| | Columbiformes | <i>Columba livia</i> | 4 | 2.3 |
| | Unidentified | | 16 | 9.0 |
| Sub Total | | | 46 | 26 |
| Mammalia | Carnivora | <i>Vulpes</i> sp. | 7 | 4.0 |
| | | <i>Felis</i> sp. | 1 | 0.6 |
| | | Unidentified | 1 | 0.6 |
| | Erinaceomorpha | <i>Paraechinus aethiopicus</i> | 3 | 1.7 |
| | Lagomorpha | <i>Lepus capensis</i> | 3 | 1.7 |
| | Rodentia | <i>Meriones crassus</i> | 11 | 6.2 |
| | | <i>Jaculus jaculus</i> | 1 | 0.6 |
| | Unidentified | | 8 | 4.5 |
| Sub Total | | | 35 | 19.7 |
| Reptilia | Squamata | Snake sp. | 1 | 0.6 |
| | | Sub Total | | |
| Carrion | | Sheep (<i>Ovis aries</i>) | 44 | 24.9 |
| | | Feral Dog (<i>Canis familiaris</i>) | 26 | 14.7 |
| | | Goat (<i>Capra hircus</i>) | 25 | 14.1 |
| | Sub Total | | | 95 |
| Total | | | 177 | 100% |

mates in Palestine, in open lowland country, including cultivated and natural fields mixed with wooded patches and sometimes with wetland adjoining. However, in Saudi Arabia, JENNINGS (2009) observed this species in similar desert habitats, with small groups of birds in open deserts with scattered dead animals. In addition, MEYBURG & MEYBURG (2010) reported satellite tracked birds wintering mainly in the Southwestern Arabian foothills savannah and to a much lesser extent in the Montane woodlands.

Migration/wintering timing and movement

The actual passage of Imperial Eagles through Jordan takes place in late September; birds have been observed in early October (Fig. 2). The majority of birds

migrate through the Eurasian–East African flyway, and migrants cross Jordan mainly through the Jordan Valley/Red Sea route and some through the Caspian–Arabian route to the east (NEWTON, 2008; ALON *et al.*, 2004). European and south-west Asian birds winter in the Middle East and north-east Africa (SNOW & PERRINS, 1998; FERGUSSON-LEES & CHRISTIE, 2001). In Arabia, six eagles were satellite-tracked to their summer home ranges; four birds migrated to Russia in spring, one to Kazakhstan and one to China, of which one spent 4.5 months in the wintering area (MEYBURG & MEYBURG, 2010).

Immature birds arrive first in Jordan, mainly in October, followed by subadults and adults. Wintering birds start to depart to breeding ground mainly in late February, few remaining birds were noted in second week of March (Fig. 2). SHIRIHAI (1996) stated that birds arrive to Palestine during the second half of October and in November with immature earlier, and depart in February and first half of March. SNOW & PERRINS (1998) also said that Imperial Eagles leave their winter quarters early with immature following adults and most arrive on breeding grounds during late March to early April. Furthermore, records from Saudi Arabia by LOBLEY (2007) support the idea that initial northerly movement may be already underway by mid February in some years.

Diet and feeding behavior

The diet of the Imperial Eagle is fairly studied on its breeding range (CRAMP *et al.*, 1980; SNOW & PERRINS, 1998; MARIN *et al.*, 2004; KATZNER *et al.*, 2005; CHAVKO *et al.*, 2007). Elsewhere, wintering Imperial Eagles are known to consume reptiles, amphibians, fish, birds and mammals (ALI & RIPLEY, 1968–1998, CRAMP *et al.*, 1980, ROBERTS, 1991–1992; GRIMMETT *et al.*, 1998). However little information is available about the eagle's diet and feeding ecology in the Middle East. The present study is the first attempt to investigate the diet of the Imperial Eagle in its winter habitat and away from its breeding ground.

Pellet analyses reflect the combined diet of adult and young wintering birds. Sampling sites were predominated by Harrah habitat, and many sampling locations (beneath power pylons) contain other uneaten food remains that could be attributed to the Imperial Eagle's frequent habit of stripping flesh from large bones (BOCHENASKI *et al.*, 1997). We identified 11 prey species to the specific level. Hares, chicken and feral pigeons are shared species with CHAVKO *et al.* (2007) and MARIN *et al.* (2004). Chickens and pigeons are more close to human settlements in the Eastern Desert.

Large domestic animal carrions comprised the major prey item consumed by Imperial Eagles (53.7%), the significance of carrions to the overall diet composition becomes even greater considering these data from a biomass perspective; the daily food requirement of Imperial Eagle is 400–600 g per day (CRAMP *et al.*, 1980). In this regard, the smaller prey species (<100 g) represented 5.26% (n = 8 items) of identified prey items. Prey between 100 and 300 g made up 17.1% (n = 26 items) of identified prey items, and prey over 300 g made up 76.97% (n = 109 items) of prey items. Only 15.59% (n = 17 items) of these larger prey were not carrion. In African, Imperial Eagle consumes mammals up to 5 kg as live prey (CRAMP *et al.*, 1980).

Avian species comprised a significant portion of eagle's diet (26.2%), with 16 unidentified species remains, essentially due to strong bone fragmentation and breakdown in eagle's crops (BOCHENASKI *et al.*, 1997). Three prey species were regularly recorded near Eagles roosting locations on power pylons; *Corvus ruficollis*, *Columba livia* and *Athene noctua*, these species formed 3.5% of Eagles diet, indicating low predation rate by Imperial Eagles. Waterfowl remains were not recovered in the collected pellets despite the presence of dams near the study area, nevertheless, Imperial Eagles congregated near water bodies for feeding and were sometimes observed attempting to steal other smaller raptors prey. Other smaller and agile resident bird remains (*Alaudidae* sp. and *Oenanthe* sp.) suggest that they were probably robbed from other smaller raptors (presumably wintering Harriers); this behavior is often observed in wintering birds in the Indian region (FERGUSON-LEES & CHRISTIE, 2001) and Imperial Eagles are adept at robbing other birds of prey and at least in some areas gains access to the bulk of its food in this manner, more maneuverable or sizeable prey is often stolen from smaller raptors or found when weak or dead (ALI & RIPLEY, 1968–1998; ROBERTS, 1991–1992). Kleptoparasitism is also relatively common among Imperial eagles in breeding grounds (DANKO & MIHÓK, 2007; CHAVKO *et al.*, 2007).

Reptiles are also popular prey, particularly in more arid habitats (BIRDLIFE INTERNATIONAL, 2001), however, only one snake skin was found forming 0.6% of the eagle's diet, despite the fact that many reptilian species are abundant in the Badia region.

Threats and conservation

General threats and conservation concerns that face Imperial Eagles during migration or wintering in the

Middle East were investigated (HEREDIA, 1996) and reflected on an International Action Plan for the Imperial Eagle. RYABTSEV & KATZNER (2007) imputed the severe decline of Imperial Eagle population in the Baikal region due to the mortality of non-breeding birds (wintering adults and all pre-adults), accentuating the possible impact of these threats at wintering quarters on the whole population.

Field observations accumulated during the present study suggest that trapping is the major threat affecting the Imperial Eagle. For example, one eagle was spotted flying with a noose trap attached to its leg near Hdelah Dam. Pellets containing Common Kestrel *Falco tinnunculus* remains collected under a power pylon where its uneaten feathers and legs were wrapped in falcons trap string, which is probably used for falcon trapping. In addition, a snake remains were found attached to a plastic rope in another pellet. All these observations suggest that eagles are subjected to trapping, either directly or indirectly, and this could be linked to the closest human settlement to these observation sites (Ar Ruwayshid), where Bedwins inhabit the area and falcons trapping is deemed an inveterate tradition; ANDREWS (1996) stated that this area has a thriving local industry selling the necessary paraphernalia for falcon catching, excessive shooting at this site.

The use of poison baits for the control of predators such as foxes (*Vulpes* spp.), Wolf *Canis lupus*, the Golden Jackal *Canis aureus* and feral dogs is a widespread activity over the region (BUDAIERI, 2000; AMR, 2000), and this often results in the accidental death of scavenging raptors, such as Imperial Eagles. Although no mortalities were recorded during this survey, pellets remains suggest the potential of eagles' mortality by poisoned carnivores. Another potential source of poisoning arise from rodenticides, where poisoning of rodents near chicken farms with mixed eagle feeding sites also reported as a common practice, especially in Qatraneh area where many pellets composed of chicken remains were found near the largest chicken farms company in Jordan. In total seven individuals were recorded near chicken or cattle farms where inappropriate dead animal waste dumping and rodenticides use observed.

Based on the present survey results and on the global and national conservation status of the Imperial Eagle, a downscaled national conservation action plan was prepared for Imperial Eagle in Jordan by the survey team (RSCN, 2007), aiming at maintaining safer wintering grounds for this species in Jordan. Participatory efforts are needed to endorse and implement the conservation outputs and measures of this proposed action plan, especially in enforcing the conservation merits of this species based on its legal status.

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