Large increase of the Egyptian Vulture *Neophron percnopterus* population on Masirah island, Oman

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Field surveys for nesting Egyptian Vultures *Neophron percnopterus* were conducted during 17 days in February and May 2012 on Masirah island, Oman. Fifty-three nesting territories were found, one of the highest breeding densities in the world; 52 were occupied by pairs. 85% of breeding territories were in the northern half of the island, where the main municipal dump was located. We estimate that there are 65–80 territorial Egyptian vulture pairs on the island (> 4 times the previous estimate), and 260–386 individuals. Of 40 pairs for which age of both breeders was determined, 38 were adult/adult pairs, one was an adult/subadult pairing and one of two subadults. Ninety-two active and old nests were found, all located in holes and crevices on steep slopes or cliffs at a mean elevation of 119 m asl (n = 32). Breeding performance was low compared to studies elsewhere, with 0.46 fledglings/territorial pair, 0.82 fledglings/incubating pair and 1.13 fledglings/successful pair being produced (n = 39). Fish and domestic livestock remains were important food sources. Unintentional poisoning and electrocution are possible threats, but there was no evidence that these threats were active. The absence of wild mammalian carnivores on the island (which can lead to poisoning events), the lack of human disturbance at the nests, and the existence of the rubbish dump and the way in which waste is handled may be the main factors contributing to the large resident Egyptian Vulture population on Masirah.

INTRODUCTION

The Egyptian Vulture *Neophron percnopterus* is a medium-sized scavenger distributed throughout southern Europe, mostly northern Africa, the Middle East, Transcaucasia, Central (Middle) Asia, Afghanistan and the Indian subcontinent (Ferguson-Lees & Christie 2001). Its historical distribution is much reduced, especially in more southern areas of Africa (Mundy *et al* 1992). In recent decades populations in many areas have declined dramatically, notably in the Balkans, Italy, Turkey, large parts of the Middle East, East Africa, Central Asia and India (BirdLife International 2012), while a few populations have been more or less stable or show slight increases (Del Moral 2009, Kobierzycki 2011, Porter & Suleiman 2012). The mainland populations on the Arabian peninsula are thought to have declined by 90% in the last 50 years (Jennings 2010).

Historical information on the Egyptian Vulture population of the island of Masirah, Oman, is available. A whole-island survey September 1944–May 1945 found 10 pairs, although the author misidentified them as Black-winged Kites *Elanus caeruleus* (Green 1949). The population probably remained stable for some time, and a survey in March 1975 estimated there to be 12 breeding pairs (Griffiths & Rogers 1975). In recent times the population has most probably increased, as suggested by the observation of more than 40 birds at the Masirah rubbish dump in May 2005 (Sargeant & Harrison 2005).

In 2008 the Egyptian Vulture was categorized as endangered (BirdLife International 2012), and since then populations have continued to decrease in a number of countries *eg* Greece (Xirouchakis & Tsiakiris 2009), Spain (Del Moral & Martí 2002), countries of central West Africa (Rondeau & Thiollay 2004, Thiollay 2006), Bulgaria (IA pers obs). Oman is thought to have a population of only *c*100 pairs (Jennings 2010). This backdrop of globally declining numbers, a purportedly small Omani population and an interest to better survey and document the birds on Masirah, an IBA (Evans 1994), provided the impetus for this survey of breeding Egyptian Vultures on the island, which aimed to collect baseline information on their numbers and distribution, and on productivity.

STUDY AREA AND METHODS

Field surveys were conducted 23 February–1 March and 9–17 May 2012 (17 days) on Masirah island (*c*20.42° N, 58.79° E), Oman. Masirah is located *c*19 km off the east coast of Oman in the Arabian sea (Figure 1); it is 65 km long and 6–16 km wide with an area of *c*649 km². Masirah is characterized by a desert landscape with hills in its central and eastern parts, reaching elevations up to 256 m asl. Vegetation is mostly dwarf-shrub, including *Limonium* and *Suaeda.* The human population is found mostly in the northern half of the island, and numbers *c*10 000. Fishing is the main livelihood, but there is also an Omani airbase on the island.

Surveys were made during *c*320 km of car travel and *c*40 km of walking into areas remote from roads and tracks. Car surveys were typically done with four people (driver and three observers). Figure 1 shows the routes travelled during surveys. Frequent stops were made along the routes and all cliffs and hills offering suitable breeding habitat for Egyptian Vultures were checked for nests, using binoculars (10×50) and a telescope (20–60×60). Given the terrain this meant that cliffs up to *c*500–1500 m from the routes were checked. The sky was scanned for vultures.

During February, territory occupancy was recorded and we tried to determine the age and breeding status of the pairs. Timing of egg laying was recorded based on observations of pairs at nest sites and age of chicks, both nestlings and already fledged young around nests. Active nests were not visited (with one exception) so as to avoid potential disturbance prior to and during incubation. Aging birds in the field followed Clark & Schmitt (1998). In May visits were made to as many nests as possible in order to record the number of chicks in the nest, investigate reasons for breeding failure, collect prey remains and record the following parameters for each nest: latitude/longitude, elevation, aspect and nest cavity dimensions. Reproductive rates were calculated excluding nests where nestlings were ≤ 40 days old because we were unsure of the survival-rate-to-fledging of such young nestlings.

Ad hoc observations were made at the municipal rubbish dump (20° 34.575′ N, 58° 52.814′ E) to get an idea of the number and age composition of vultures using the dump.

RESULTS

Fifty-three occupied breeding territories were located (Figure 1), 52 were occupied by pairs and one by a single territorial bird. Of these, 45 (85%) were located in the northern half and 8 (15%) in the southern half of the island. Thus, at a minimum, the nesting density of the Egyptian Vulture on the island is 8.17 pairs per 100 km²; the mean nearest neighbour distance was 1.02 km (range: 120–6670 m). In total 92 nests were found. Nests were always in holes or crevices on very steep slopes or cliffs that had an abundance of potential nesting cavities (Plate 1). Nest sites were located high up (mean elevation 119 m, n = 32) on ridges and hills that were remote from human habitation and also provided good protection from the weather. At least 93% of the nests located were accessible without the use of climbing equipment. Nests faced mainly north (8), east (7) and west (5). On average, nesting cavities (n = 21) were 115 cm wide, 113 cm

Plate 1. Egyptian Vulture *Neophron percnopterus* breeding habitat within a large wadi in the northern part of Masirah island, Oman. © *Ivaylo Angelov*

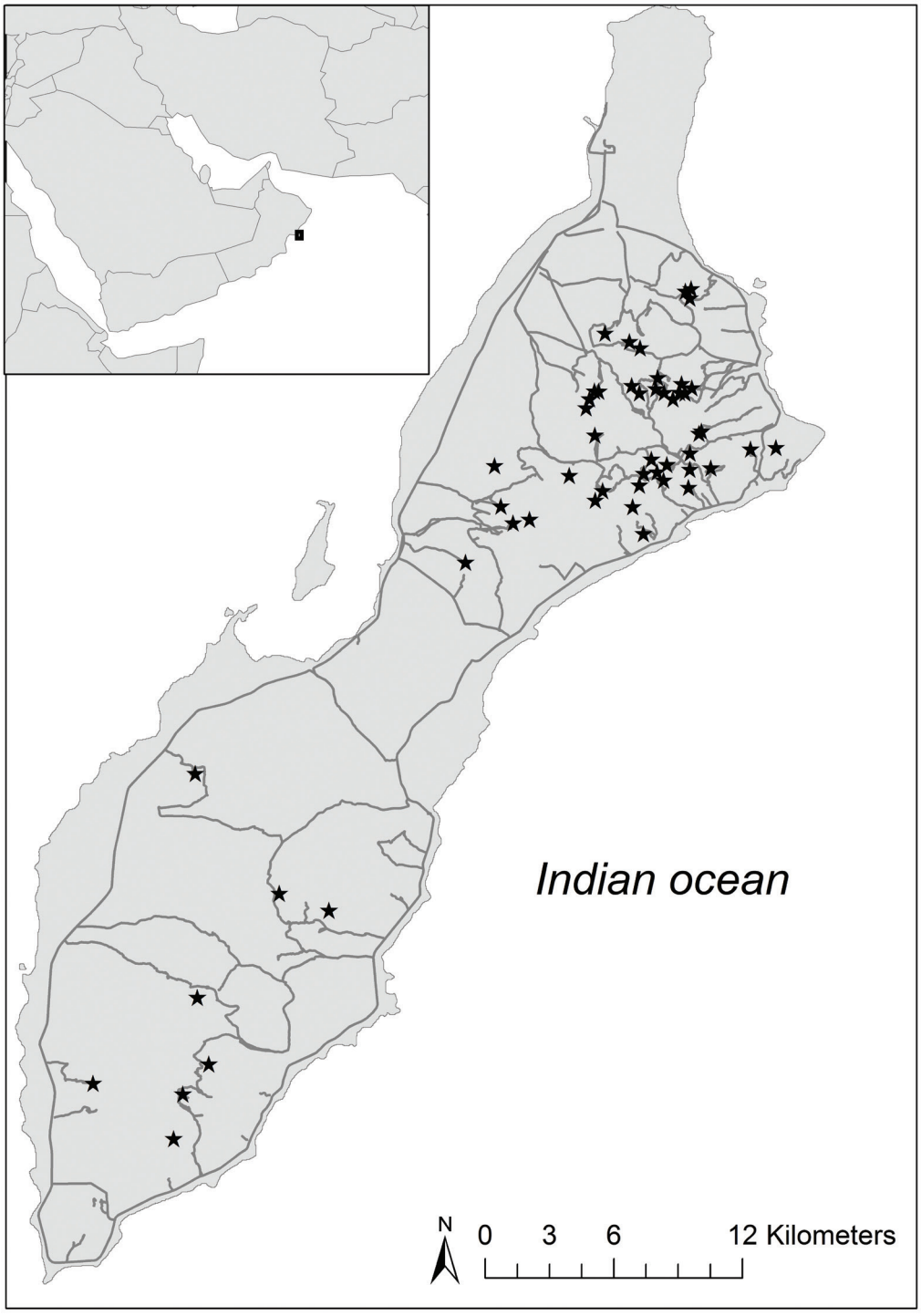

Figure 1. Locations of the 53 Egyptian Vulture breeding territories (asterisks) and survey routes (lines) travelled on Masirah island, Oman.

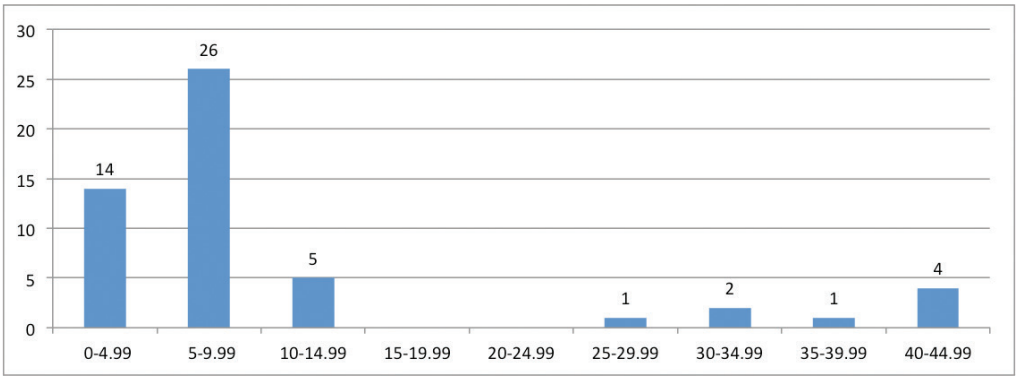

Figure 2. Distribution of Egyptian Vulture breeding territories (n = 53, vertical axis) in relation to the distance (km) to the municipal rubbish dump on Masirah, Oman, in 2012.

deep and had an entrance height of 74 cm (Plate 2). Density of nesting territories was apparently higher in the vicinity of the rubbish dump (Figure 2).

Egyptian Vultures on Masirah laid eggs October–March (n = 25, Figure 3), with most laying in January and February. It is possible that some pairs may lay eggs during May–September, but the timing of our surveys precluded determining this. Of 42 pairs examined, 25 (59.5%) laid eggs (Plate 3). Reproductive data from three nests were excluded from further analyses because one was still incubating in May and the nestlings at two were <30 days old when visited in May. Six of 22 pairs (27.2%) failed during incubation or lost their young after hatching. Thus, 18 nestlings >40 days of age were produced from 16 pairs that hatched eggs (Plate 4). Egyptian Vultures on Masirah produced 0.46 juveniles per monitored pair (n = 39), 0.82 juveniles per breeding pair (n = 22), and 1.13 juveniles per successful pair (n = 16).

Plate 2. Fully feathered juvenile Egyptian Vulture *Neophron percnopterus* (lying at back) in deep and well sheltered nest cavity, Masirah island, Oman. © *Ivaylo Angelov*

Prey remains from 10 nests were collected. All contained fish and domestic livestock remains, and these animal groups probably represent the main food source for the Egyptian Vultures on the island. Remains were also found of gulls *Larus*, a single domestic cat *Felis catus* and a single Brown-necked Raven *Corvus ruficollis*. The only significant congregations of foraging vultures were observed at the municipal rubbish dump (Plate 5), where up to 26 birds were observed (Table 1). Smaller, apparently ephemeral, groups were seen at locations around the island (Plate 6). Immature and adult Egyptian Vultures were also observed roosting communally on east and south facing cliffs at higher elevations, particularly in the area of Jabal ash Shabbah, *c*6.5 km south of

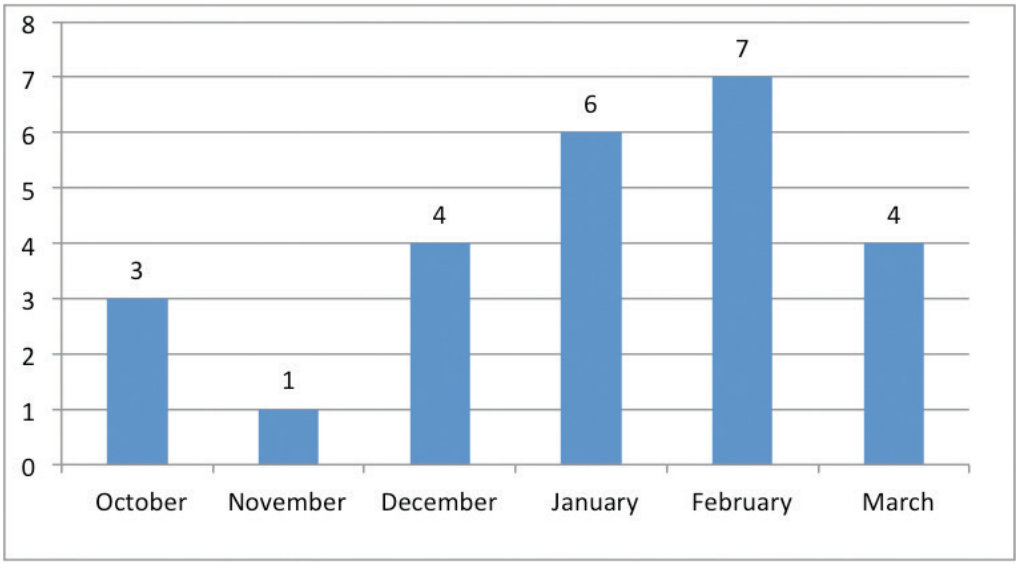

Figure 3. Timing of egg laying (n = 25) for Egyptian Vultures on Masirah, Oman, in 2012.

the rubbish dump. On 14 May, 18.00–19.30 h, one such roost held 35–38 Egyptian Vultures, including 18–20 immatures (apparently non-territorial birds).

DISCUSSION

Our survey confirmed 53 occupied breeding territories of Egyptian Vultures on Masirah, which is almost 4.5 times the number previously thought to be breeding on the island (Griffiths & Rogers 1975). Given the increase in human population in recent years, and thus the increased amount of waste being disposed of at the rubbish dump, it seems likely that at least some of the increase is real and not the result of improved survey. Although we recorded many more territories than previous observers, some pairs were most certainly missed by us because we did not survey all areas on the island, and the time frame of field work was limited. Taking into account the amount of apparently suitable habitat that we did not survey and the effect nearness to the dump site had on the density of territories we estimate the current breeding population to be 65–80 breeding pairs (*ie* a 5.4–6.6 fold increase from previous reports). Our findings clearly suggest that the Oman national population size of the Egyptian Vulture is underestimated at 100 pairs (Jennings 2010). MJM (unpublished data) counted 15+ hatchling Egyptian vultures from the year at two different rubbish dump sites (the main dump for Muscat and at Quriyat) in northern Oman in August 2012. It is likely that many if not all of those would have been produced

Table 1. Egyptian Vulture age structure at the municipal rubbish dump on Masirah, Oman, 2012. 1st plumage refers to juvenile bird.

Date	Time	1st plumage	2nd plumage	3rd plumage	4th plumage	Adult	Total
23 Feb	07.30–08.30 h	0	7	4	1	10	22
9 May	08.10–08.25 h	0	1	1	0	12	14
11 May	14.45–15.00 h	2	5	1	0	18	26
15 May	06.50–07.05 h	0	3	1	0	8	12

at nest sites in Oman because migrants from more northern areas would not have arrived in Oman by then. This evidence of productive nests in northern Oman supplies additional support to the idea that Oman's breeding population of Egyptian Vulture is larger than 100 pairs.

Donázar *et al* (2002) found that 33.6% of Egyptian Vultures on the Canary islands off northwest Africa were breeders. If one assumes that the ratio of breeders to non-breeders on Masirah is similar and that the confounding influence of movement between the islands and mainland is not very different between the Canaries and Masirah (see Agudo *et al* 2010a, b), then the number of Egyptian Vultures on Masirah is estimated to be at least 386. The minimum size of the Masirah population can also be estimated by using the ratio of immatures to adults at the rubbish dump in spring (Table 1). So, with 65 breeding pairs, comprised almost entirely of adult/adult pairings and a ratio of adults to immatures at the dump site being *c*1:1, it can be conservatively estimated that 260 individuals occur on the island. Five visits were made during different parts of the day to the Masirah rubbish dump on 11–12 October 2012, and counts of the vultures there were made from different vantage points. A maximum of 76 vultures was observed, comprising birds of all ages, including birds reared in 2012 (ESO unpubl data). These October counts do not undermine our island population estimate, but highlight a confounding aspect: the potential existence in October of non-territorial birds that were reared on the mainland or in other nearby countries (see Cunningham 2002, Meyburg *et al* 2004).

Nest site locations on Masirah (high steep slopes) are like those reported by Green (1949) and, taking into account the lack of predation pressure on Masirah, the locations of nest sites were similar to those used by island populations elsewhere (*eg* Gangoso & Palacios 2002). We did not analyse all factors that might affect spatial distribution of territories (*eg* distribution of suitable nesting sites or distribution of human habitation), but this lack of analyses does not detract significantly from the impression that the rubbish dump is important. Survey effort, as measured by the length of the routes, was not systematically biased and so the north–south difference in breeding density is probably not a sampling effect. The density of breeding territories was highest around the rubbish dump, almost certainly because it is a reliable source of food for the vultures. Most waste collected by the local sanitation services and from private fishing boats is brought to the dump, and thus it provides an abundant and relatively stable source of food for vultures. Timing of breeding recorded on Masirah appears to be slightly later than on Socotra

Plate 3 (left). Egyptian Vulture *Neophron percnopterus* nest with four eggs, one of which lacks pigmentation, Masirah island, Oman. Worldwide, we know of no record of Egyptian Vulture clutch size > 3. © *Ivaylo Angelov*

Plate 4 (right). Two Egyptian Vulture *Neophron percnopterus* juveniles (at back) in nest showing individual plumage variation, Masirah island, Oman. © *Ivaylo Angelov*

Plate 5. Egyptian Vulture *Neophron percnopterus* perched on the fence of Masirah island's municipal rubbish dump, Oman. © *Ivaylo Angelov*

Plate 6. Egyptian Vultures *Neophron percnopterus* are commonly seen feeding on road kills or on dead domestic animals disposed of near roads, Masirah island, Oman. © *Ivaylo Angelov*

Table 2. Distances from the municipal rubbish dump on Masirah to nest sites of Egyptian Vulture pairs known to have failed at the egg or nestling phase.

	Pair 5	Pair 11	Pair 12	Pair 16	Pair 24	Pair 25
Distance to rubbish dump (km)	8.08	2.53	7.2	8.32	37.48	8.83

and slightly earlier than elsewhere on the Arabian peninsula (Jennings 2010, Porter & Suleiman 2012). However, our data are from a single year and we do not know how timing of breeding varies between years. Also, because timing of breeding could be affected by food availability, the existence of the rubbish dump on Masirah might contribute to a lack of variability in timing of nesting.

Twenty-seven percent of the reproductive pairs failed at the egg or chick stage. It is unclear why these nests failed, and Table 2 shows no clear spatial pattern. That at least one nest close to the dump site failed suggests that nest failure is not always due to lack of food. Further study could determine whether proximity to the rubbish dump is related to long-term productivity. However, timing of breeding and the onset of territoriality and the consequent ranging that is more focussed on the nest may also influence the effect of the rubbish dump on breeders. The reproductive rates on Masirah (0.46 fledglings/territorial pair, 0.82 fledglings/breeding pair and 1.13 fledglings/successful pair) are the lowest of which we are aware (Abuladze & Shergalin 1998, Cortes-Avizanda *et al* 2009, Donázar *et al* 2002, Garcia-Ripollés & López-López 2006, Kobierzycki 2011, Liberatori & Penteriani 2001, Margalida *et al* 2012, IA pers obs Bulgaria). As stated above with regard to nesting density, proximity to the rubbish dump may affect reproduction. A study of a dense population in Turkey that preferentially foraged at a rubbish dump, found large variation in breeding success between two consecutive years (Şen *et al* 2011). A long-term study is needed to better understand the scale of annual variation in breeding success and to properly establish the reasons for the apparently low breeding performance on Masirah, and whether density dependent effects are evident.

Domestic livestock and fish remains were the main food consumed by the vultures. Local people report that a species of catfish (*Arius* sp), which has little commercial value, is discarded if caught, and this may result in tens or hundreds of such fish washing ashore on some days, where they become food for the vultures (Plate 7). The importance of this sometimes plentiful food source could be the basis of further study.

POTENTIAL THREATS AND CONSERVATION

At present the high density of breeders, large proportion of adult/adult pairings and good numbers of immatures (though some of these may be immigrants from the mainland) suggest that the Egyptian Vulture population on Masirah is healthy. While we saw almost no evidence of any major active threats to the vultures on Masirah, vulture populations can be affected by factors that increase mortality (Plate 8) or reduce breeding success, including direct and indirect poisoning, electrocution, declines in food availability and habitat loss (Donázar *et al* 2002, Hernandez & Margalida 2009).

The breeding density of Egyptian Vultures on Masirah (8.17 pairs per 100 km²) is extremely high, exceeded only by once-dense urban populations (Alleon 1876, Galushin 1971) and probably by the extant population on Socotra (Cramp & Simmons 1980, Margalida *et al* 2007, Porter & Suleiman 2012). While the rubbish dump is a source of consistently available food and is normally beneficial to the vultures, vultures feeding there could be affected if poisoned or contaminated material is available. Because vultures will feed in aggregations, single contamination incidents can have disproportionate effects

Plate 7 (above)**.** Egyptian Vulture *Neophron percnopterus* feeding on a fish that has been washed ashore, Masirah island, Oman. © *Ivaylo Angelov*

Plate 8 (right)**.** Dead adult Egyptian Vulture *Neophron percnopterus* found in a wadi relatively high in the hills, Masirah island, Oman. © *Ivaylo Angelov*

on the Masirah population or even the wider population (Tewes 2002). Currently, local herders on Masirah do not appear to use poisons and there are no large predators on the island that threaten domestic livestock. This situation is similar to that on Socotra (Porter & Suleiman 2012), where Egyptian vultures also occur at very high densities. Local people on Masirah reported that vultures used to very occasionally attack newborn livestock, but it is not known whether this behaviour still persists or is decreasing due to the increased amount of other food available to the vultures on the island.

Hunting is forbidden in Oman, and as long as it remains so, illegal shooting probably has little impact on Egyptian Vultures on Masirah and throughout the country. In recent years networks of medium-voltage power lines have been installed on the northern side of the island. The pylon design used in this network (Plate 9) is potentially dangerous because large birds such as Egyptian Vultures could be electrocuted when perching on them if they touch a wire with a wing. Quite a lot of work has been done in other parts of the world to design acceptable ways of constructing power lines and pylons that are not dangerous to birds (*eg* Jenkins *et al* 2010). Discussions with the electricity company should be initiated to better understand this potential, and change the design of the power lines and pylons to more bird-friendly types. The effect of these power lines on Egyptian Vultures on the island (and other soaring birds) is unknown, and should be studied. Although it seems that there are currently few problems, this threat may grow because electrification of the island will undoubtedly expand.

Changes in food availability, availability of secure sites for nesting, and other influences, such as the potential modernization of waste disposal could negatively affect the Egyptian Vulture population on Masirah. The increasing human population in Oman, including on Masirah, along with living standard changes, is likely to increase the amount of waste of all types being disposed. While we are unaware of any plans to modernize waste disposal on Masirah, improvements in waste management are being made in other parts of the Sultanate. The effects of modernizing waste disposal management in Oman

Plate 9. Egyptian Vulture *Neophron percnopterus* perched on electricity pylon, with vertical insulators above a horizontal crossbar, a design type that is considered dangerous in terms of electrocution risk, Masirah island, Oman. © *Ivaylo Angelov*

on vultures are not known, and observations are ambiguous. Based on a limited number of surveys at dumpsites in northern Oman (Al Balushi *et al* 2013), more modern waste disposal does not necessarily mean a decline in vulture numbers using dumpsites. The most modern waste disposal site in Oman, at Al Multaqa, which receives most of Muscat's biological waste, is used by large numbers of avian scavengers (>230 Egyptian vultures counted at times during October 2012). Conversely, no vultures were observed on other sites where disposal is less modern *eg* Barka (two visits) or Samail (one visit), which had an apparent abundance of food including carcasses of camels, goats, sheep and cattle.

The management of waste is an important aspect to consider for the conservation of scavengers (including vultures), and there is a tension between the desire to dispose of waste in a way that supports human health benefits and a way that makes food available for vultures. In Europe, for example, stricter animal carcass disposal laws were put in place due to concerns about the possibility of diseases (*eg* BSE) spreading to humans, and as a result food availability to scavengers dropped and special dispensation needed to be given to so called 'vulture restaurants' that provide safe and plentiful food for avian scavengers. Additionally, globally, there is a lack of information about health effects to vultures of scavenging at rubbish dumps, including the potential for infection by pathogens, ingestion of residues of veterinary drugs or other contaminants, and other potential effects (Blanco *et al* 2007). Against a background of global conservation challenges to avian scavengers and likely improvements to waste disposal in Oman, it is important that strategies for waste disposal in Oman address the human health element,

but do not undermine conservation. For example, perhaps 'vulture friendly' areas within some dumps could be established, where suitable certified-'clean' organic waste could be dumped under professional supervision, and thus ensure the availability of safe food for vultures and other avian scavengers. Modern and traditional dump sites in Oman and elsewhere are attractive to scavenging raptors (mostly vultures and eagles), and this makes the dump sites attractive to birdwatchers, including those from other countries. Indeed, bird-watching blogs and internet sites (*eg* www.fatbirder.com/links_geo/middle_east/oman.html) highlight dump sites in Oman as good places to see birds. So, while potential conservation benefits are obvious, there would also be benefits to tourism that could be enhanced, first probably on the mainland and then later on Masirah, especially if dump site managers, municipalities, conservationists and the tourism industry work together to improve the sites for scavengers.

Although no plans have been made there have been discussions by government agencies about the possibility of building a bridge connecting Masirah with the mainland. Such a bridge, if realized, would enable an increased flow of people and investments onto the island. As in other parts of the world, a bridge may also provide access to the island for mammalian predators (*eg* foxes), and this could expose adult Egyptian Vultures, their eggs and offspring to predation. Predictably, some ground predators (*ie* cats, dogs, and rats) do occur on Masirah, but currently their distribution appears to be around human habitation and away from areas used by vultures for nesting. During the surveys only a single car with tourists was encountered in the inner parts of the island where Egyptian Vultures breed. At present, disturbance from recreational activities during the breeding season does not seem to be a concern on Masirah.

We know that there is a large annual influx of scavenging birds to Arabia from more northern areas during the non-breeding season. It is not known what proportion of birds observed at the rubbish dump came from places off the island. The distance to the mainland (19 km) is not as large as at Socotra (*c*240 km), and we do not believe it is an insurmountable barrier to immigration and emigration. Satellite tracking of Egyptian vultures, whether from Masirah or elsewhere, could help clarify the situation. Even if one assumes that the distance to the mainland is not a barrier to movement, it is almost certain that Masirah is not a sink population. However, given the apparently low productivity, it is also not clear to what extent the population is a source of birds that will breed elsewhere. We also could not rule out density dependent effects influencing productivity, nor, as mentioned above, whether the number of birds of all age classes combined was a result of immigration. Obviously, if the Masirah island population of Egyptian Vultures is contributing breeding birds to sites away from the island then the importance of the island population in terms of regional and global conservation is increased.

Fruitful avenues of future work exist on Masirah including the clarification of whether birds on the island come from elsewhere or leave the island to breed. Opportunities exist to build local expertise in surveying, monitoring, and conducting research on vultures on the island, and using the Egyptian Vulture to promote conservation of wildlife there. The situation on Masirah offers possibilities to better understand general features of Egyptian Vulture ecology and biology, the ecology of island populations, and provide information on Egyptian Vultures at the regional scale, highlighting the importance of Arabia for its resident and visiting Egyptian Vultures.

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