

Has Sooty Falcon *Falco concolor* distribution contracted in Oman?

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Oman is a stronghold for breeding Sooty Falcons *Falco concolor*, a Near Threatened species that has a patchy breeding distribution in the Middle East and northeast Africa. Monitoring changes in the distribution of breeding falcons within stronghold states is important for conservation. Data from surveys 2007–2014 and from the Oman Bird Records database and other sources were used to create distribution maps of breeding Sooty falcons for pre 2000, 2000–2004, 2005–2009 and 2010–2014 in Oman. Analyses of historical and current information sought to discern patterns and trends in distributional extent. As in the past, the main breeding concentrations are on the islands in the sea of Oman, especially the Damaniyat islands and Fahal island. Small numbers of pairs breed on the Sawadi islands and at locations on the coast to the southeast of Muscat. Numbers of breeding pairs on the Musandam peninsula and associated islands appear to be very low, and may have been so at least since 1990. There is some evidence of individual pairs breeding on the coast of southern Oman near Ras Madraka and As Shuwaymiyah. Although data from an intensive study 2007–2014 show that numbers of breeders has decreased, the geographical distribution appears similar to what it was in the 1990s, but this similarity is a product of the scale at which Sooty Falcon distribution has been reported. Reporting at the ½ degree latitude/longitude scale is not sufficient to monitor distributional change, especially because important portions of the population can breed colonially on islands. Reduction in breeding distribution can affect population recovery, especially if dispersing birds show fidelity to natal sites or if recruitment is facilitated by the presence of other breeders. For this reason, and especially because Oman is distant from the main breeding distribution centred on the Red sea, an important conservation goal is to maintain the geographical distribution of Sooty Falcons in Oman by limiting development in breeding areas and controlling human disturbance during the breeding season. Scope exists for improved wildlife monitoring in the Sultanate, for the Sooty Falcon and other species, by harnessing the interests of Omani biologists and citizen scientists.

INTRODUCTION

The nature of a species' distribution, and any spatial or temporal trends in numbers, affects its vulnerability to threats, and is used, along with information on survival and reproduction, to measure and monitor the health of populations and determine a species' conservation status (IUCN 2012). In this context, investigation and documentation of the distribution of migratory species with broad ranges requires detailed long-term research and monitoring, often in many locations. One such species is the Sooty Falcon *Falco concolor*, categorized as Near Threatened on the IUCN Red List (BirdLife International 2017). The global Sooty Falcon population is small and declining, although estimates of population size and severity of decline may not be accurate (BirdLife International 2016). This falcon is also listed as a Category 1 species under the Raptors MoU initiative of the Convention on Migratory Species (Convention on Migratory Species 2015).

Although considered a breeding stronghold for Sooty Falcons (Walter 1979, Gaucher *et al* 1995), recent data suggest the species is declining in Oman (McGrady *et al* 2017) as a result of poor survival (McGrady *et al* 2016) and possibly human disturbance in breeding areas (McGrady *et al* in press). The only detailed information on past Sooty Falcon distribution in the country comes from the single-year survey by Walter (1979). Eriksen & Victor (2013) provide a distribution map based on information held in the Oman Bird Records (OBR) database with records dating from 1917, although only 12 records pre-date 1970 (Eriksen 2016). As a stronghold for this species, which has a wide and patchy breeding distribution, it is important to monitor closely its distribution in Oman.

The Sooty Falcon preys mostly on birds (especially during the boreal summer) and insects (especially during the boreal winter), and breeds during the boreal summer,

feeding its nestlings on songbirds migrating in the autumn. Its breeding range extends from the deserts of Libya in the west to coastal Pakistan in the east, and from Israel in the north to the Red sea islands of Djibouti in the south; almost the entire population spends the non-breeding season (hereafter, 'winter') in Madagascar and coastal Mozambique (Gallo Orsi *et al* 2014, BirdLife International 2016). Sooty Falcons can nest singly, mostly in mainland areas where the migration of their prey is along a broad-front of relatively low volume, or on small islands. On larger islands along the flyway where migrating prey species are concentrated, Sooty Falcons will nest in loose colonies.

Only a few pairs of Sooty Falcons breed on the east coast of the Arabian peninsula beyond Oman (Kavanagh & King 2008, Shah *et al* 2008), and the Oman breeding population is over 1800 km away from the nearest breeding concentrations in the Red sea. Being so isolated suggests that recruitment of breeders may be impeded, especially because survival and, perhaps, immigration are low (McGrady *et al* 2016) and contribute to low population growth in Oman (McGrady *et al* 2017).

Here we document the current distribution of the Sooty Falcon in Oman using a compilation of all available data for 2000–2014. We examine the species' distribution in three 5-year periods (2000–2004, 2005–2009 and 2010–2014) and compare these with the species' distribution before 2000. These data provide an important frame within which to consider recent analyses of survival (McGrady *et al* 2016), reproduction and population growth (McGrady *et al* 2017). We also discuss the importance of monitoring and reporting distribution at scales that can detect change. Such improvements in monitoring and reporting will assist in conservation planning for this species by informing predictions of population persistence in Oman, an important outcome in light of Oman's status as a breeding stronghold.

METHODS

We collated Sooty Falcon observations submitted to the OBR database during 2000–2014 (Eriksen 2016), and during 2007–2014 we gathered information on the occurrence of breeding Sooty Falcons by searching areas of nominally good nesting habitat (*ie* cliffs, rocky crags and steep, rocky terrain near the sea; Walter 1979) during July–November (Plate 1). Searches were made by boat and on foot along cliff-rich coastal areas of the mainland and islands, mostly in northern Oman. Boat-based searches were made by 1–4 observers, using binoculars, and a boatman travelling slowly along the coast (< 100 m from shore); searches on foot were made by 1–6 observers walking in nesting habitat, sometimes with the help of observers in a boat.



Plate 1. Fahal island 27 September 2014, a globally important breeding site for Sooty Falcons *Falco concolor* in Oman, is typical of the habitat searched for nesting Sooty Falcons. The island is regularly patrolled offshore by the Royal Oman Police. © M McGrady

Table 1. Areas searched for Sooty Falcons 2007–2014

Area	When	Method
Al Fahal island	annually in August and September–October 2007–2014	boat, foot
Al Damaniyat islands	annually in August and September–October 2007–2014	boat, foot
As Sawaydi islands	August and September–October 2007, 2008, 2014	boat
Musandam (mainland and islands, Khasab– Dibba)	13–17 October 2014	boat
north and northeast coast (Ras al Hamra– Quriyat)	16–17 September 2014	boat
Halaniyat islands	23–25 October 2014	boat



Plate 2. A recently hatched Sooty Falcon *Falco concolor* chick and unhatched eggs in a nest on the Damaniyat islands, Oman, 17 August 2014. © WA Al Fazari

During 1 August–10 October our focus was on the islands in the sea of Oman (= gulf of Oman) because of an intensive study we were conducting on Sooty Falcons breeding there (McGrady *et al* 2016, 2017). Surveys in other parts of the presumed Omani breeding range were conducted after 5 October. At that time almost all chicks have fledged (McGrady *et al* 2017), and are still in the vicinity of the nest, which made it less likely that productive territories would go unrecorded. The areas searched included the mainland and other areas of good nesting habitat on the coast and on islands, which coincided with areas searched by Walter (1979): Muscat to Quriyat (c65 km), Al Fahal island (Plate 1), the nine Damaniyat islands and the seven Sawadi islands in the north, and the five Halaniyat islands in the south; we also surveyed the Musandam peninsula and the islands around it, in the north (c479 km; Table 1). Because of time constraints, we did not search the mountains south of Muscat, for which evidence of past nesting is poor (Walter 1979, Eriksen 2016), and which are used by ground predators (eg Arabian Red Foxes *Vulpes vulpes arabica* and feral cats *Felis*



Plate 3. A ringed territorial adult Sooty Falcon *Falco concolor* in attendance near its nest site, Damaniyat islands, Oman, 24 September 2013. Such territorial behaviour indicates the existence of a nearby nest. © WA Al Fazari



Plate 4. Ringed Sooty Falcon *Falco concolor* nestlings, surrounded by prey remains in their nest, Damaniyat islands, Oman, 22 September 2015. © WA Al Fazari

catus), and are increasingly disturbed by residential and commercial development. We also did not search the inland areas of the Musandam peninsula or the three, small and remote islands north of the peninsula (As Salamah archipelago).

In areas visited, Sooty Falcon breeding status was categorized as Confirmed (*ie* productive nest scrape found or non-productive nest scrape found (and at least one non-adult falcon in attendance, or recent fledglings observed in October (Plates 2–4) or Probable (at least one adult in attendance in an area of suitable nesting habitat 15 July–31 October, with or without behaviours consistent with breeding; *eg* food passes, food begging), and locations were recorded using a global positioning system. We also compiled records of sightings of Sooty Falcons for July–October 2000–2014 held in the OBR database (Eriksen 2016) and sightings by reliable sources (*ie* researchers, competent birdwatchers and citizen scientists), for the same period, of apparently breeding Sooty Falcons not reported in the database, and assigned a status of Confirmed, Probable or Possible to each record based on the date on which the observation was made, data on productivity and observer notes associated with the record and on past observations of falcons where the record occurred. In a similar manner we compiled records of all pre-2000 sightings of Sooty Falcons held in the OBR database (Eriksen 2016), and assigned them a status of Confirmed, Probable or Possible in the same manner.

RESULTS

The OBR database holds 553 records of Sooty Falcon up to 2014, of which 307 were prior to 2000, and the earliest from 1917 (a museum specimen). Of the pre 2000 records, 294 were Confirmed, Probable or Possible breeding records (Table 2). The database contains 238 breeding records for 1 July–31 October 2000–2014. Of these, 17 were in areas not surveyed by us, including records from the south coast and southeast of Sur; 14 of these were made before our more intensive survey of 2007–2014. We compiled a total of 509 breeding records of Sooty Falcon in Oman for 2000–2014: the 238 from the OBR database, nine from four other observers, and 262 from our own surveys. Of these 117, 208 and 184 records were for the periods 2000–2004, 2005–2009 and 2010–2014 respectively.

Sooty Falcons in Oman are concentrated on the islands in the sea of Oman (As Sawadi islands, Al Damaniyat islands, and Al Fahal) and some mainland areas characterised by cliffs and steep rocky terrain located around and to the southeast of Muscat (*eg* Bandar Jissa, As Sifah and Ras Abu Douad; Figure 1). In northeastern Oman apparently single pairs were observed near Qalhat (7 October 2010) and Ras Al Kabbah (4 October 2002, Eriksen 2016), and in the south near Ras Madrakah (October 2011) and As Shuwaymiyah (21 September 2002).

Table 2. Number of Confirmed, Probable and Possible breeding records of the Sooty Falcon in Oman before 2000 (from Eriksen, 2016) and during three 5-year periods from 2000 onwards (2000–2004, 2005–2009, 2010–2014; from our surveys, records from four other observers, and Eriksen, 2016).

	Pre 2000	2000–2004	2005–2009	2010–2014
Confirmed	176	33	157	165
Probable	93	49	14	10
Possible	25	35	37	9
Migrant	13	2	6	0
Total	307	119	214	184
Total without migrants	294	117	208	184

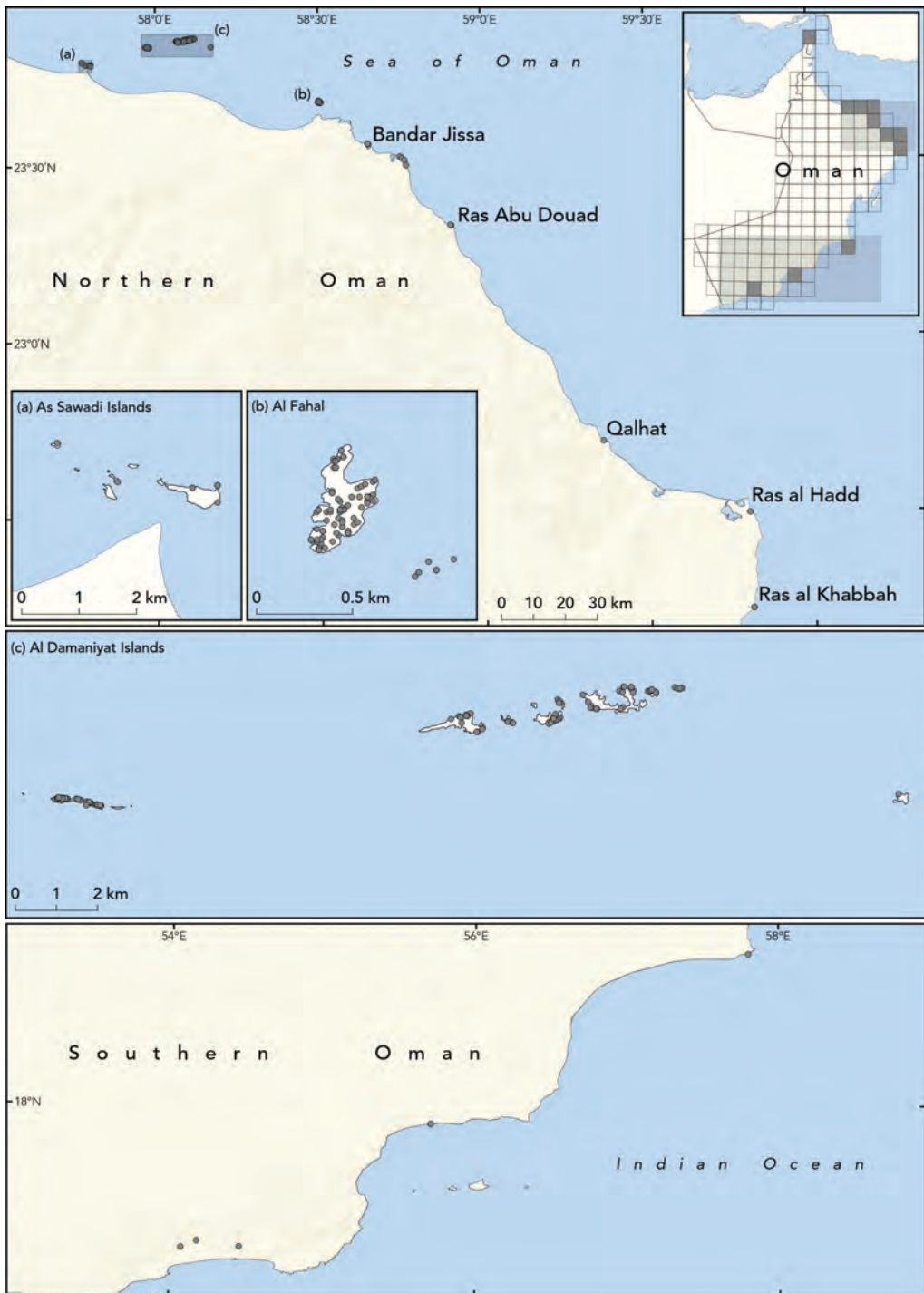


Figure 1. Individual records of breeding Sooty Falcons (Confirmed, Probable and Possible records combined, see text for details) on the islands and coast of northern and southern Oman during 2000–2014 (data compiled from the Oman Bird Records database, competent observers, and our own surveys), with individual details of (a) As Sawadi islands, (b) Al Fahal island, and (c) Al Damaniyat islands in the north. Inset upper right: country-wide Sooty Falcon distribution in Oman for 2000–2014 summarized from all Confirmed, Probable and Possible breeding records to $\frac{1}{2}$ degree latitude \times $\frac{1}{2}$ degree longitude (the same resolution used by Eriksen & Victor 2013).

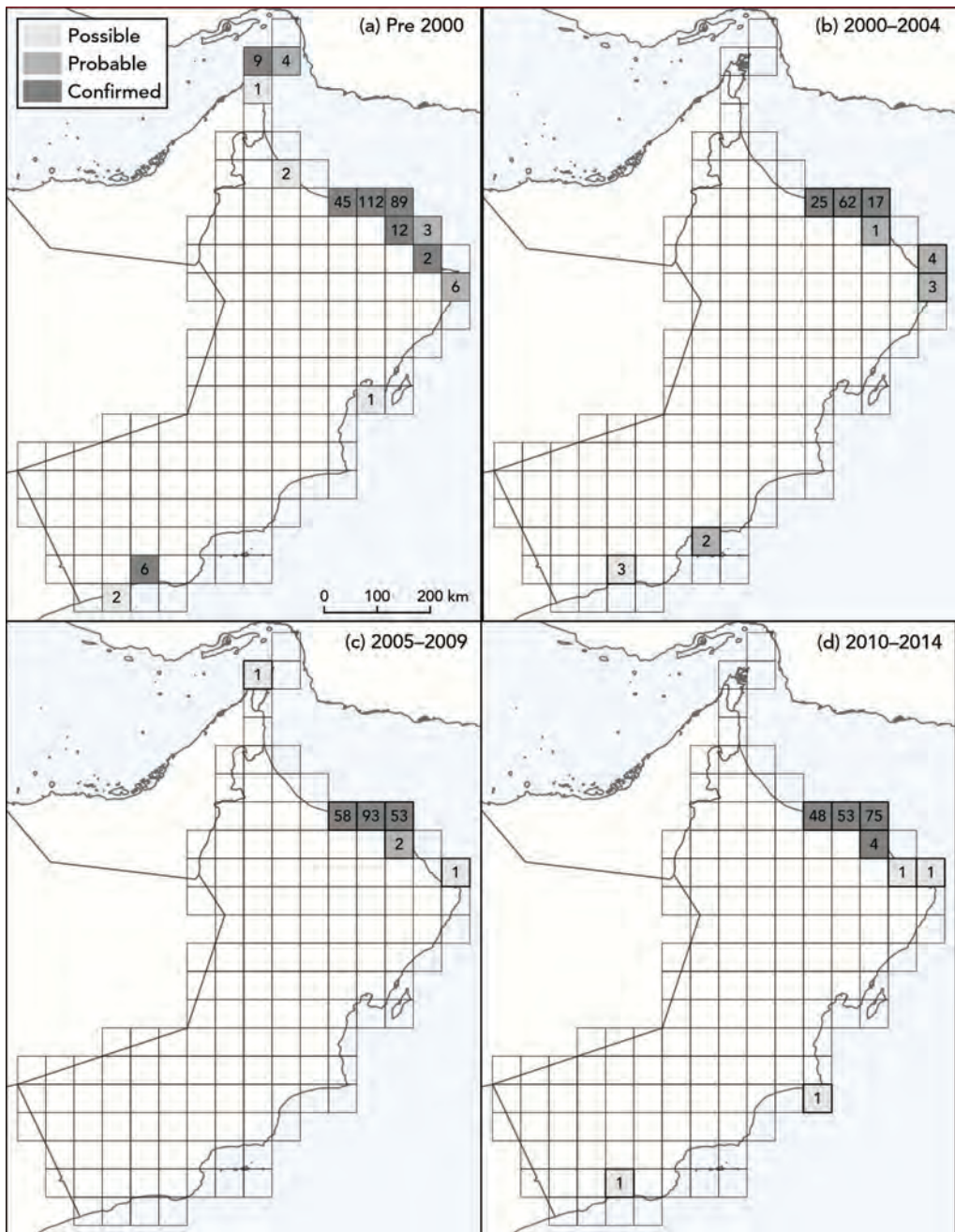


Figure 2. Distribution of breeding Sooty Falcons in Oman summarized to $\frac{1}{2}$ degree latitude \times $\frac{1}{2}$ degree longitude cells, resolution used by Eriksen and Victor (2013), for (a) 1917–2000, data compiled from the Oman Bird Records database; Eriksen (2016), (b) 2000–2004, (c) 2005–2009, and (d) 2010–2014 (data compiled from the Oman Bird Records database, competent observers, and our own surveys), categorized as Confirmed, Probable and Possible (see text for details). The numbers in each square indicate the total number of records for that square irrespective of breeding categorization.

No breeding Sooty Falcons were seen in Musandam during our survey in 2013, although two adult birds were seen at two different locations along the western coast (13 October 2011, 26.28°N, 56.32°E) and islands (14 October 2011, 26.38°N, 56.42°E; M McGrady

unpublished), and there was a sighting of an adult on 31 October 2008 near Khasab (c26.21°N 56.26°E, Eriksen 2016).

Figure 2 shows the distribution of records of Confirmed, Probable and Possible records of Sooty Falcons breeding (a) prior to 2000, (b) during 2000–2004, (c) 2005–2009, and (d) during 2010–2014, summarized to ½ degree latitude × ½ degree longitude cells (the resolution used by Jennings 2010 and Eriksen & Victor 2013). In all time periods confirmed breeding was concentrated on the islands of Fahal, Damaniyat and Sawadi. The mapped distribution of breeding birds post 1999 appears similar in the three 5-year periods but compared to before 2000, the distribution is more restricted, with few breeding records in Musandam or in the south, and none of these Confirmed.

DISCUSSION

The current distribution of breeding Sooty Falcons in Oman (Figures 1, 2(d)) is concentrated mostly on the islands in the sea of Oman (Fahal, Damaniyat and Sawadi islands) and coastal cliffs southeast of Muscat. In that respect it mirrors earlier reports of falcon distribution (Walter 1979, Eriksen *et al* 2003, Eriksen & Victor 2013, Figure 2a–c), and reflects their ecological needs in terms of food availability and nesting habitat. Those islands occur in only three ½ degree latitude × ½ degree longitude squares (Figure 2). Differences between the distributions of observations of suspected breeding during different time periods are largely because some reported in Eriksen *et al* (2003) and Eriksen & Victor (2013) were from areas not visited by Walter (1979) *ie* Musandam, As Shuwaymiyah and Ras Madrasah. Those differences comprise a few isolated pairs away from the main breeding area near Muscat, and are not inconsistent with a declining population, as suggested by McGrady *et al* (2016, 2017). Interpretation of differences in numbers of breeders between time periods should, however, be treated with caution because effort has varied with time.

The Musandam peninsula appears to be an important geographical feature that might concentrate migration of falcon prey (particularly in spring) and has abundant nesting habitat, some of which is on predator-free islands. Although Walter (1979) did not survey for falcons in Musandam, he speculated that it could hold significant numbers. Breeding of a few pairs in Musandam was confirmed in the 1980s (Figure 2a, Eriksen 2016), and suspected in more recent years (Eriksen *et al* 2003, Eriksen & Victor 2013, McGrady unpublished data), but our extensive survey there in 2013 by experienced observers at a time of year when fledglings should have been flying yielded no sightings. The 13 breeding records in the OBR database (two Confirmed, four Probable and seven Possible) span 1973–1990. The majority of these were from the As Salamah archipelago, which was not visited during our 2013 survey, but taken together the evidence suggests that probably only a few Sooty Falcons breed in Musandam. So, despite the potential for breeding, Sooty Falcons are only scarcely distributed on the peninsula today, and there is little evidence that a significant breeding population has occurred there in recent times. McGrady *et al* (2017) discuss the potential impact of food availability during June–July on Sooty Falcon reproduction. Shortage of food during that time may cause otherwise suitable areas to be unoccupied or to be abandoned early. Musandam does not hold any colonies of breeding seabirds (Eriksen & Victor 2013), nor does it have any nearby cities or towns that might be a source of early breeding season food for Sooty Falcons (see McGrady *et al* 2017). Thus, the apparently low density of breeding falcons on Musandam may result from low prey availability early in the breeding season rather than a lack of nesting locations or low food availability during chick rearing.

Human disturbance and coastal development have been implicated in distributional restriction of the Sooty Falcon in other parts of Arabia (Kavanagh & King 2008, Shah *et al* 2008), and respondents to a range-wide questionnaire identified human disturbance and

developments in breeding areas as major threats (Gallo Orsi *et al* 2014). McGrady *et al* (2017, In press) suggest that the population of breeding Sooty Falcons has declined, and survival appears low (McGrady *et al* 2016). Those declines are not apparent in the data used in this study; over time numbers of confirmed breeding has not shown any trend (Table 2). However, such data are observer biased and do not account for variation in effort over time. As noted above, the distribution of breeding Sooty Falcons seems similar to what it was in the 1990s, when mapped at the ½ degree of latitude/longitude scale. However, the scale at which distribution is reported can affect conclusions (Levin 1992, May 1994), which, in turn, can affect conservation planning, especially when accurate population size estimates are missing.

Past reports of Sooty Falcon distribution in Oman were made at ½ degree of latitude/longitude or island-group scales (Walter 1979, Eriksen *et al* 2003, Eriksen & Victor 2013). We also report at those scales, so as to make like-to-like comparisons. Mapping distributions on a coarse scale is an important first-step in understanding them, and is necessary and practical for widely distributed species.

However, when considering a species like the Sooty Falcon, which often nests in aggregations, such reporting and comparisons may actually mask distributional constrictions because losses are occurring at a finer scale (*ie* the island). The situation in Oman illustrates this well, where the great majority of breeding occurs in an area of 75 km × 25 km (*ie* c0.75 degrees of longitude × 0.22 degrees of latitude), and when mapped occurs in just three ½ degree latitude/longitude squares. Large declines (> 60%) in the breeding population on the Daymaniyat islands, including extirpation on some of the islands, could be entirely masked by reporting at this scale alone. Because Oman is a breeding stronghold for this species, it is important that monitoring and reporting is at a scale that is sensitive to change (*ie* island-scale). Such monitoring and reporting is important for other stronghold countries, including Eritrea, Egypt and Saudi Arabia.

It is possible that finer scale reporting might risk increases in poaching or persecution. Some of the reasons that this does not seem valid in this case include: published information has been available since the 1970s (Walter 1979); their existence on the islands where they aggregate is fairly well known amongst the public; Sooty Falcons are typically not used in falconry or persecuted by pigeon-keepers; Oman has no tradition of falconry; and there is abundant evidence that poachers and persecutors are competent at finding nests when they are motivated to do so. If, however, a precautionary approach is desirable, detailed reports to the ministries that aid in conservation could be labelled as confidential, and public reports made at a coarser scale.

Sooty Falcons seem to show at least some degree of natal fidelity (McGrady *et al* 2016), so maintaining distributional extent can be beneficial to population recovery. This is especially true in Oman for a number of reasons, including the country's status as a breeding stronghold and its location on the edge of the breeding range, far from other breeding concentrations. Given these characteristics of the Oman Sooty Falcon population and beyond any need to address low survival, it is important that breeding areas in Oman remain undeveloped, and that protection in areas where colonies exist is strengthened. In particular, policing of human activities and resisting encroaching development, especially at officially designated protected areas such as the Damaniyat islands (designated 1996 as a National Nature Reserve, Royal Decree 23/96, IUCN category IV), is essential. In light of its geographic isolation and despite the coarse scale of reporting, the apparent spatial stability of the Sooty Falcon breeding distribution in Oman is a positive finding in terms of conservation. However, low population growth rates (McGrady *et al* 2017) and poor survival (McGrady *et al* 2016) point to a declining population, and at some point this will result in a reduction in spatial distribution.

Oman is building its capacity to monitor and protect its wildlife resources. Data on animal distributions can be collected not only by professional scientists, but also by the public and citizen scientists, facilitated by easy-to-use tools such as smartphones (eg Obsmapp, www.obsmapp.org) and digital cameras, and different data types can be combined for the purposes of research and conservation (Mazzolli *et al* 2017). Despite its name, the African Raptor Databank (2017) extends to cover the Arabian peninsula and observations of Sooty Falcons and other raptors in the OBR database can be used to model species distribution. Most bird (and other) atlases and surveys, even in developed countries, rely largely on volunteer effort by non-professional enthusiasts (eg Balmer *et al* 2013, North American Breeding Bird Survey, www.pwrc.usgs.gov/bbs/) guided by a relatively small number of experts. The OBR database, which was important to this study and to our knowledge of occurrence and distribution all bird species observed in Oman, relies entirely on volunteers, the majority of whom have a great deal of enthusiasm and practical expertise, but little formal ornithological training. With minimal training and some guidance, Omani government, academic, and NGO biologists, as well as citizen scientists, could become the core of a wildlife monitoring programme, including for the Sooty Falcon, that benefits wildlife and people by linking them to the rich natural world around them (Dutton 2016).

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