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Department of Animal Science and Food Processing

Bird communities at an offshore island of Abu Dhabi, Sir Bani Yas, UAE

PhD Thesis

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DECLARATION

I hereby declare that I have done this thesis entitled "**Bird communities at an offshore island of Abu Dhabi, Sir Bani Yas, UAE"** independently. All texts in this thesis are original, and I have provided a complete reference to the resources that are used in this document according to the citation rules of the Faculty of Tropical AgriSciences. All figures and photographs are either by myself or are used with authorisation and quoted author.

In Prague, 3rd of March 2021 ..…………………………..

Bilal Kabeer

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ABSTRACT

In hot arid ecosystems, birds are vulnerable due to changing, mostly warming, climate, reducing already scarce resources and impacting birds' fitness. In deserts, human-made modification of habitats and intensive management represent potential mitigation measures to defeat these risks. Birds are recognized as important indicators of the state of the environment. Because they are sensitive to habitat change and they are easy to census, changes in bird populations are often the first indication of environmental problems. Sir Bani Yas is an important bird area and bird sanctuary as well as a wildlife reserve. The aim of the present dissertation thesis was to bring an insight into the bird communities at the Sir Bani Yas Island (SBYI), the largest off-shore island in the United Arabian Emirates in the Arabian Gulf. The investigation was focused on several parameters to characterise bird communities and their responses to the given environment. These parameters included; enlisting avian species, their feeding guilds, migratory and conservation status along with seasonal and inter-annual dynamics of the species richness, species diversity and equitability in bird communities in regard to habitats. Moreover, breeding performance of selected species, namely common kestrel (*Falco tinnunculus*), osprey (*Pandion haliaetus*), and Saunders' tern (*Sternula saundersi*), with a focus on species abundance, nesting sites, clutch size, hatching success, and overall fledging success was studied. The island was categorized into four habitat types i.e. Forest, Coastal areas, Mountains and Pastures. Two transects of 800 × 100 meters were laid in each transect type. The data was collected from January 2014 until December 2018 through visual observations with the aid of binoculars and spotting scopes. Birds were identified through standard field guides. The observations on the breeding of osprey (*Pandion haliaetus*), common kestrel (*Falco tinnunculus*) and Saunder's tern (*Sternula saundersi*) were recorded from January 2014 until May 2018. For this purpose, the nests were marked and were monitored until the chicks flew off the nest. We found the SBYI hosted a total of 164 bird species of all feeding guilds, Charadriiformes and Passeriformes being the most abundant, while there were 9 bird species before the SBYI was managed. The highest species richness and diversity was on irrigated pastures (mean 40.1 ± SE 1.4 species, mean Shannon-Wiener index H = 3.0 ± SE 0.03), followed by coastal area (mean 31.5 ± SE 0.7 species), forest (mean 22.0 ± SE 0.7 species), and rocky desert mountain (mean 21.3 ± SE 0.6 species). In all habitats, bird communities transformed following seasons, the species richness and diversity being highest in colder period while decreased during hottest months, the most on pastures and coast. Most species were migratory, suggesting the SBYI as a stepping stone supporting ecological connectivity in desert. Six nests of Saunders's tern (12 nests total) were selected in each breeding season from April to June 2017 and 2018 (out of 9 and 8 nests, respectively). The mean clutch size during the two-year period was 1.50 ± 0.22 and 1.33 ± 0.21 (Mean ± SE) eggs per nest in 2017 and 2018, respectively. The mean incubation period was 18.97 ± 0.33 days. The mean hatching success was 62.5 % and 45 % in 2017 and 2018, respectively. Out of the 12 nests, three nests did not produce any fledglings, as one nest failed due to predation by feral cats and two due to anthropogenic factors. In common kestrel the courtship and nesting started during early April and the eggs were laid during late April. The average clutch size was 3.75 ± 0.31 eggs per clutch. The average incubation period was 29.13 ± 0.52 days resulting in average hatchlings of 3.50 ± 0.53 chicks. The eggs were incubated 74.02 ± 1.69 % and were unattended for 24.54 ± 1.64 % of the total incubation period. The provision of nesting platforms was successful in enhancing the reproduction rate of the Ospreys on the island. The nests on platforms were more successful in producing fledgelings compared to nests on natural substrates in disturbed habitats and with interspecies competition for nesting sites. The provision of platforms reduces competition for nesting sites and provides safety to adults and young. Our results indicate that ecological modifications on the SBYI coupled with protection of natural habitats provide a unique mosaic, which supports avian communities, and enhance ecosystem heterogeneity with the broader impact in the Arabian Gulf ecoregion. The finding of this study could be used as future reference to study the breeding success of the species and provide cues for further improvement of the ecosystem conditions by improving the habitat condition at the Island.

Keywords: arid environment; artificial habitats; avifauna; biodiversity; breeding; community structure; ecosystem modification; extensive vegetation management; habitat management; migratory routes; species co-occurrence; wildlife conservation

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Chapter 1

INTRODUCTION

Birds are vital part of ecosystems and have manifold ecological functions. Birds occupy many trophic levels in the food chain ranging from consumers to predators and their occurrence has been helpful for plant seed dispersal, as plant pollinators, pest controllers as well as environmental health indicators. Bird communities are excellent bioindicators of the climate change, land-use alteration and/or urbanisation effects on ecosystems. Since they are highly diverse and conspicuous elements of the ecosystem. In addition, they respond rapidly to changes in landscape configuration, composition, and function. As a result, they are used as prompt indicators of habitat changes, both degradation and restoration alike (Bideberi 2013; Ramchandra 2013). Successful breeding complements a healthy and intact ecosystem; any changes in breeding success can immediately provide cues for degrading ecological health that can be a result of environmental changes or anthropogenic catastrophes (Ronka et al. 2011). However, to analyse these effects and aim the interpretations towards the conservation and management interventions, the knowledge of the natural behaviours and variations in the breeding biology of the birds is essential. Breeding success is critical for the maintenance of viable populations of birds (Ronka et al. 2011).

According to the International Union for Conservation of Nature (IUCN) (2009), over 1200 (12%) of the world's bird species are considered threatened with extinction (i.e., in the categories of Critically Endangered, Endangered, Vulnerable and Extinct in the Wild). Additionally, 838 species are considered Near Threatened. Thus, a total of 2065 species are urgent priorities for conservation action (Pedro & Regina 2012). One of critical threats for bird species diversity, population abundance, and communities is the loss of habitat and habitat degradation, among which the loss of forest cover has a specific position. The forest cover is decreasing globally at an alarming rate, principally due to human forest overexploitation, land conversion, or mineral resources extraction. It causes the loss of ecosystem bonds, processes, and services, sharp decline of the biodiversity. Further amplification of effects of climate change on large spatial scales cause deserts to expand into the previously productive (e.g. arable) land (Bremer & Farley 2010).

About 10% of avian and mammalian species of the world occur on the islands, whereas, the total area of the world's islands is just less than 2%. Islands are also known as the most suitable locations for speciation, contributing to a large number of endemic species of different classes. Mostly, the island exhibits unique biological and geological characteristics, as they were mainly undisturbed sanctuaries for unique species (Johnson & Stattersfield 1990). Environmental factors and invasive species are significant culprits for the massive population decline of the island birds (Collar et al. 1994; Stattersfield & Capper 2000; Hahn et al. 2011).

Extensive vegetation management and land modifications are common practices around the world to increase the plantation volume of an area (Lambin & Geist 2006). Their aims can be commercial for timber production, soil conservation, improve degraded and disturbed habitats, or covering barren land to improve carbon sequestration and climate, and fighting desertification. The man-modified habitat management such as afforestation may have either a positive or negative impact on biodiversity. The magnitude and direction of this impact is influenced by the land use after plantation, local forest management practices, and the tree species planted (Hunter 2000; Carnus et al. 2006; Marquiss 2007; Brockerhoff et al. 2008; O'Connell et al. 2012). Planted forests enhance faunal diversity when such practices are done in areas of low biodiversity value, such as agricultural land, and arid or desert land (Freedman 2007; Iremonger et al. 2007; Brockerhoff et al. 2008). Planted forests impact bird diversity through a diverse, interacting array of mechanisms. These mechanisms may include richness and abundance of the food resources and prey. Moreover, these habitat modifications provide different ecological niches for a diveristy of birds. They also provide numerous breeding and nesting sites and migratory stop overs. These modifications also add to the availablility of new territories and foraging grounds, thus, promoting dispersal and local migrations (Gardner 2010).

Extensive plantations and cultivations all over the UAE and more particularly in the Emirate of Abu Dhabi have considerably increased the greenery in the country. Such green areas are major attraction for many species of birds, mainly winter migrants. The green areas on island and desert are important, particularly for migrating birds to feed and rest. The extensive inter-tidal mudflats, tidal lagoons and mangroves support up to 300,000 individuals of waterbirds during migratory season. Most of these migrants are from Europe and Asian countries. It is belived that an annual turnover of 2.5-3 million birds occur during the spring and autumn migration. This turnover of waterbirds is due to high productivity of the gulf waters (Butler et al. 2001).

More than 473 bird species have been recoreded from the UAE (Javed 2008). The importance of bird conservation is not only because of the diversity of species but also due to the presence of regional and internationally important breeding and wintering numbers of many bird species. At least five species of terns (*Sterna* spp.) have important breeding colonies restricted to islands. Eight flyways for shorebirds have been identified in the world. Birds coming to the UAE take East Africa -West Asia (Afro-Eurasian) and Central Asia-South Asia flyways. Historical accounts of ornithology are limited (Javed 2008). However, recent studies by Environment Agency Abu Dhabi (EAD) have highlighted the importance of islands for seabird conservation and some key islands for bird conservation have been identified and proposed for further proctection. There are 14 different identified habitat types in the UAE including four main habitats for birds; the desert, coasts and mudflats; parks and gardens; and mountains and wadis (Javed 2008).

The United Arab Emirates has many near shore and offshore islands. Both near shore and offshore islands are most important areas for conservation of avifauna in the UAE. Sir Bani Yas is the largest natural island and startegically important for bird species. Landescape, plantations and cultivations all over the island have incresead bird attaraction, mainly for the wintering migrants. The International Bird Association (IBA) programme aims to identify, monitor and protect a global network of sites critical for the conservation of the world's birds and other wildlife. Over the past four decades, the IBA programme has identified and documented over 12,000 sites globally, amounting to around 6% of the world's surface area. A total of 30 IBA site has been recorded in UAE, including Sir Bani Yas Island.

Sir Bani Yas Island is located in UAE which was developed as a wildlife reserve for the conservation of endangered species declared as a wildlife reserve in 1971, and since that time it went through a lot of ecological modifications. The island was transformed from barren, arid land to suitable habitat for more than 160 migratory and resident bird species by the plantation of more than two million trees. This aims to provide suitable habitat to the endangered wildlife brought to the island for conservation (Mehmood et al. 2014). Before, the island was barren and unoccupied with no confirmed reports of existing fauna. With extensive vegetation management, the island started welcoming more bird species (Pei et al. 2018).

It is imperative to study the contributing factors that are responsible for the population dynamics of birds' species, over-whelming phenomenon of bird diversity, their distribution over a particular type of habitat, and their breeding success. This knowledge base will provide a better image of their further distribution both in human-inhabited or natural habitats (Bideberi 2013) and basis for further effective conservation measures. The avifauna of Sir Bani Yas Island has not been studied in this context before, and there is a significant gap in the information at hand to evaluate and recommend conservation interventions. This particular study was designed to assess the diversity, habitat utilization, and breeding of selected bird species, thereby to contribute to the assessment of effectivity of conservation strategy so far and give basis for next conservation planning and decision-making. The species for the study of breeding performance and biology were selected based on gaps in the knowledge about their breeding success (Saunders's tern), being apex predator representing the effects of the man-made modifications on the overall ecological health (common kestrel), and based on the conservation interventions to improve breeding success, such as provision of artificial platforms (osprey).

Chapter 2

AIMS OF THE THESIS

The aim of the present dissertation thesis was to bring an insight into the bird communities at the Sir Bani Yas Island (SBYI), the largest off-shore island in the United Arabian Emirates in the Arabian Gulf, in regard to the land management applied on habitats at the island which is partly leaving habitats as naturally desert, and partly modified and intensively managed, creating thus artificial habitats rich in vegetation cover and food resources. The investigation was focused on several parameters to characterise bird communities and their responses to the given environment. To achieve this broader aim, particular objectives were determined as follows:

Objectives:

1. To determine bird species which inhabit the SBYI, their feeding guild, migratory, and conservation status;
2. To determine the seasonal and inter-annual dynamics of the species richness, species diversity and equitability in bird communities in regard to habitats, i.e. in natural desert and coastal, and in artificial, intensively managed habitats which are planted and irrigated forests and pastures;
3. To assess the bird community structure, species mutual relationships, and species co-occurrence in these habitats on the island, with a special focus on temporal (seasonal) dynamics;
4. To assess the breeding performance of selected species, namely common kestrel (*Falco tinnunculus*), osprey (*Pandion haliaetus*), and Saunders' tern (*Sternula saundersi*), with a focus on species abundance, nesting sites, clutch size, hatching success, and overall fledging success.

Chapter 3

REVIEW OF LITERATURE

Birds belong to class aves of the phylum vetebrata and have evolved into a diverser group of approximately 10,000 species over a course of 150 million years. There are approximately 23 bird orders, 142 families, 2,057 genera, and 9,702 species in the world (Koenig 2016).

Birds are one of the principal classes of vertebrates, surrogated as ecological health indicators. They assist in the assessment of changes in the ecosystem, ecological health, and effects and risks to the ecological set up by climate change and anthropogenic activities (O'Connell et al. 2007). They strongly influence the conservation efforts due to aesthetic and cultural affinity of humans to their charismatic presence. Moreover, birds are susceptible to changes in their populations over a few generations, providing an early warning for the need of conservation efforts. It, in turn, leads to the conservation of the less conspicuous species in the ecosystem (Koenig 2016). Birds of prey can endorse increased biodiversity by both facilitation of resources and making them available to species that could not otherwise avail them, and by trophic cascades, i.e. by affecting the trophic levels (Sergio et al. 2008). Top predators are used as conservation tools and are very effective to determine ecological health (Rönkä et al. 2011).

Status, threats, and habitat

More than 40% of avian species are declining globally. The major threats are habitat loss due to agriculture and forest depletion for timber, contributing to the decline of approximately 50% threatened species. Other factors include decline due to invasive or alien species (39%), illegal trade (35%), climate change (33%), and expansion of human settlements (28%) (BirdLife-International 2018). Since the first comprehensive bird species assessment in 1988, there has been a continuous decline in the species and many species have gone extinct, while others crawled to the threatened status over few decades. The populations of nearly 40% avian species are declining. Whereas, 44% species are stable, approximately 7% have seen population increase, and the trend of 8% is not known (BirdLife-International 2018).

The effects of road reconstruction and restoration activities on birds such as Sand martin (*Riparia riparia*), European bee-eater (*Merops apiaster*) and European roller (*Coracias garrulus*) nesting at roadside suggest that total population number of these species and nests decreased during and after the road broadening and construction efforts. These three species failed to find alternative nest area affected by habitat destruction caused by road construction works. In the urban environment birds have a lower variety of breeding than in natural environments and their density and number may often more or less (Nergiz & Durmuş 2016).

Environmental disturbances are significant culprits for the massive population decline of bird species from their habitat and resulting in drastic population decline. The abundace and diversity of birds are used as indicators of long-term environmental disturbances both natural and anthropogenic which include climate change, unprecedented events such as droughts or storms, intensive urbanisation and land use change (Collar et al. 1994; Stattersfield & Capper 2000; Hahn et al. 2011).

For a successful conservation intervention of avian species on islands, it is necessary to study the contributing factors that are responsible for the population dynamics of the birds' species, including both decline and rise of population. It is imperative to study the over-whelming phenomenon of bird diversity and their distribution over a particular type of habitat. This knowledge base will provide a better image of their further distribution in both in human-inhabited or natural habitats (Bideberi 2013).

Extensive vegetation management is a common practice around the world with an aim to promote vegetation cover (Bremer & Farley 2010; Lambin & Geist 2006). However, it has both positive and negative implications (Graham et al. 2017). Several studies have been done on the effects of extensive vegetation management on biodiversity. Most of the studies have been executed on invertebrates followed by birds, mammals and plant species (Stephens & Wagner 2007). About three-quarters of these studies suggest a negative impact on bird diversity if the planted forestation is replacing natural forest cover, whereas, it is also observed that if extensive vegetation management is done in a disturbed habitat or where there was no forest earlier, the bird diversity and abundance increases (Hartmann et al. 2010).

Vegetation plays a crucial role in determining habitat preferences of birds. Birds have habitat preference based on the diversity and structure of vegetation. Studies on birds from eight different types of grasslands and found that more than half of the bird's preference was associated with the variation in the diversity of the vegetation, and 35 % were associated to the structure of vegetation strands. It can be affirmed that birds chose habitat based on particular type of vegetation schemes which in turn provide them with particular kind of food, shelter, escape and breeding ground as required by their behavioural and biological parameters (Rotenberry 1985). Species composition of birds is not correlated with physiognomy (vegetation structure). Species richness of birds does not suffer from invasion of non-native plants, if the vegetation community retains sufficient structural diversity. The composition of the bird community is closely related to floristics, and other taxonomic groups may exhibit different responses to vegetation structure and composition. Therefore, explicit strategies for landscape-scale management, restoration and maximization of native faunal diversity should consider how removal of invasive plants might affect physiognomy and floristics of the vegetation community as a whole (Bailey et al. 2014).

Islands are an integral part of global biodiversity above 10% of avian and mammalian species of the world occur on the islands whereas, the total area of world's islands is just less than 2%. Islands are also known as most suitable locations for speciation, contributing to a large number of endemic species of different classes. Mostly, the islands exhibit unique biological and geological characteristics, as they were mainly undisturbed sanctuaries for unique species (Johnson & Stattersfield 1990). Due to human encroachment and land degradation, many of islands became the platform of species extinctions (Reid & Miller 1989; Pimm et al. 1994; Steadman 1995; Steadman & Martin 2003; Blackburn et al. 2004).

Three significant factors are known to contribute towards avian species' extinction *viz.* habitat degradation, small range and intrusion of alien species to their range. As birds on the islands tend to be specialists and endemic to a smaller range, they have a higher predisposition towards extinction (Johnson & Stattersfield 1990; Rodrigues & da Cunha 2012). As an estimate, bird species inhabiting islands are almost 40 times more susceptible to extinction compared to the species on the mainland. Therefore, the islands encompass around 40 % of threatened bird species globally. Moreover, out of the total avian species found on islands, up to 90 % are confined to a smaller number of islands only. Adding up to the dilemma, mostly island species have low population sizes leading to an increased threat of extinction (Johnson & Stattersfield 1990; Pimm et al. 1994). The species niche on the islands also determines their range and population sizes. For instance, some species may have lower numbers on the island, but they thrive well on mainland and vice versa (MacArthur & Wilson 1967). During the study in 2007, no evidence of breeding Sooty Falcons were found at Dinah, Sir Bani Yas and Delma islands indicating a possible loss of territories due to disturbance. During the current the study and detailed survey, no Sooty Falcon was reported and recorded on Sir Bani Yas Island (EAD 2014).

The expansion of an avian species range depends on the availability of the suitable habitat conditions. For instance, specific biological and behavioural requirements by birds require specific habitat features for their survival. The habitat preference of the birds is linked to the availability of resources and adjustment with the environmental conditions. Among various vegetative habitats damp and scour habitat types had abundant bird species (Mota et al. 2011). Fowls prefer habitats with shrub cover, herbaceous layer, dense shade with nearby trees (Dragomir et al. 2017). Mangroves and mudflat areas contribute towards the most densities and diversities of avian species. Moreover, the shorelines also have high birds congregations. The nearshore and oceanic ridges have fewer inhabitants as compared to wetlands (Zogaris & Kallimanis 2016).

Feeding guilds

Feeding guilds can be defined as ecological units of various animal communities and serve as building blocks for various ecological communities (Anthal & Sahi 2017). Species that require similar ecological resources and that use same ecological niche are grouped together in the same guild, and it does not take into consideration the taxonomic status of the species. Moreover, it also depends on the habitat features and available resources of a particular area. Usually the feeding habits of the birds determine their placement into different feeding guilds. The classification of feeding guilds of class aves depends on their particular feeding habits such as; feeding strategy, types food items consumed, selection of foraging substrates, and vertical levels at which foraging occurs. The feeding strategy and habitat use for foraging are key factors that are mostly used to assign a given feeding guild to a species. Moreover, various species in a given feeding guild usually differ in terms of their specific food requirements. Thus the chances of intraspecific competition are reduced, even with limited resources. The information of feeding guilds of various species provides an insight to the community composition of a specific habitat and also of different habitats. It also provides an overview of how different species utilize a given set of habitat resources avoiding any conflicts (Anthal & Sahi 2017).

Bird population, migrations, richness and diversity

The avian species richness and diversity is a pointer of the wellbeing of the habitat. It is essential to study these parameters to correlate them to the other factors such as habitat utilisation, climatic and anthropogenic factors (Bideberi 2013). The land birds on island ecosystems have higher species diversity and abundance as compared to the shore and freshwater birds. Moreover, the land birds in these ecological settings perform better in terms of breeding success, on contrary to the other two categories mentioned-above (Hahn et al. 2016). Avian species groups on the mainland are more various and for the most part less bunched than island fledgling groups and not unique in relation to arbitrarily collected groups. Avian groups on islands have a tendency to be practically comparative and phylogenetically bunched, particularly on little and secluded islands (Si et al. 2017). The aggregation of bird species in the islands is related to the habitat conditions of the island that are similar to their original range (Johnstone et al. 1996).

One of the charismatic phenomena of the class *Aves* is migration. They can migrate large distances even across continents to find suitable habitats, foraging, and breeding grounds. Moreover, dispersal is also observed in the birds. It is an evolutionary adaptation to cop with the variations in the climatic and other environmental conditions in their habitat. The migratory patterns differs even in closely related species and even if they share same habitat. It also includes the migratory routes that differ in species that may either have same breeding or non-breeding grounds. On the other hand, dispersal is regarded as short movements of birds from their natal territories to the surrounding localities. It is also a critical process as not all birds succeed in dispersal. The migrations of birds can be categorised as facultative migrants (that migrate only under certain conditions and not on an annual or seasonal basis), obligate migrants (that migrate annually to breeding and non-breeding grounds), partial migrants (are species in which some individuals migrate and other stay behind), and nomadic species (those that move unpredictably and do so in large numbers) (Winkler et al. 2016).

The duration and routes of migration vary among birds species. Some bird species travel for short distances, rest, and restart their journey. While others prefer to take single long flights to reach their destinations. Both strategies have different pros and cons e.g. the great snipe (*Gallinago media*) prefers to take a direct flight with speeds of over 100 km/h. While some thrush species tend to take resting and foraging breaks. The continuous flight may cause exertion, fatique and strong evolutionary adaptation. On the other hand breaks during migration may pose risk to predation and disease (Klaassen et al. 2011).

The population of species can be termed as individuals of that particular species sharing the same habitat at a given time (Koenig 2016). The population size is one of the important attributes of the animal population. The bird populations constantly change and are susceptible to the external changes. The changes in the bird populations provide a baseline data to assess whether the population is decreasing, increasing, or is stable during the given time period. Moreover, it gives other important information such as population demography, fecundity, and survivorship (Koenig 2016). It required extensive studies over the course of several years to correctly describe the population demography and composition, especially the wild populations.

Additionally, the population demography is also affected by abiotic and biotic factors. The population demography is essential to determine spatial and temporal distribution of a given bird species, especially the habitat preference. The population size is regulated by density-dependent and density-independent factors. Density dependent factors are those affected by the population size of a given species e.g. availability of food and other resources. Whereas, density-independent factors are not affected by the population size such as natural catastrophies (fire, storm, etc.). Moreover, social behaviour has also been attributed to regulate the population of a bird species e.g. territorial behaviour directly influences the population dispersal and breeding rate in a given habitat (Koenig 2016).

The populations of birds may fluctuate over time. These fluctuations may be periodic e.g. seasonal variations in the population of a given habitat. The reasons for these fluctuations may be due the abudance or scarcity of the prey, or other food items, or due to climatic variations such as rainfall or drought. These fluctuations may affect the survivability of a species if it already has low population or it is confined to a narrow geographical range. In these scenarios, the metapopulations play essential role in species survival givent that there is sufficient dispersal between these populations and that there is very low spatial synchrony between these populations (Koenig 2016).

Bird communities may be defined as a set of various ecologically interacting bird species in a given habitat and time. A similar term that is coined to address a group of birds occupying same area in a given time is species assemblage. When studying bird diversity, two critical assumptions are considered, first is the number of species in a community and the second is their relative abundance. Where, species richness may be termed as the number of species present in a community (Greenberg 2016).

Species area relationship is critical aspect of island birds diversity. According to the theory of island biogeography the number of species on island is based on an equilibrium between colonisation rates (decline if the distance of island is greater from the nearby continent) and exitinction rates (decline with increasing size of the island). Studies have shown that number of bird species double with a ten-fold increase in the size of an island. Smaller islands tend to support lower population of species due to the availability of the area and resources along with the fact the these small populations can to migrate if the climatic conditions become adverse and are prone to extinction. Similar fact is true for other fragmented or small habitats and man made island (Robinson et al. 2004). There is a strong relationship between the habitat type and a bird community structure and composition. If a habitat is disturbed, the bird community will change in a predictable way according to the restoration of the habitat and also according to the successional stage of the habitat. Bird species are also prone to area sensitivity and may not thrive below a certain size of habitat or fragment (Greenberg 2016).

Breeding biology

Birds are adapted to breed in a number of habitat types successfully i.e. from the freezing antarctic region to the hot deserts, tropical rain forests, and mountains. The birds have a narrow margin in terms of time to have a successful breeding season. It is due to various contributing factors such as climate, food availability, prey abundance, and the presence of predator (Winkler 2016).

One of the crucial factors that determine the timing of the breeding season is the availability of food to the chicks. Most of passerines usually feed on insects, therefore, the parents tend to lay eggs while still the insect abundance is on rise. Similarly, species that forage on seeds, usually choose different time or season when that particular feed item is abundant. Similarly, the birds of prey will choose the time of the year when there is abundant prey species in the area to feed their young. The changes in the seasons are usually minor and the birds are clocked to breed in the same season every year. Moreover, photoperiod (duration of day length) is one of the most important factors in determining the time of the breeding season. Another contributing factor for determining the breeding season of birds especially in arid environments is rainfall. Some species just rely on the environmental cues and breed any time of the year depending on the availability of the resources e.g. crossbills in the northern hemisphere initial breeding when the pine seeds are available. Similarly, rock pigeons breed year-round depending upon various seeds of plants and other scraps from humans. However, these birds have to keep their reproductive systems ready and thus expend extra energy as compared to the strictly seasonal bird species that shut their reproductive systems when not breeding (Winkler 2016).

Another important aspect of the breeding biology of birds is maintaining breeding territories. Especially for males, it is one of the most costly behaviour in terms of the energy expenditure along with risk of serious injuries or even death. The birds defend their territories for several reasons but mainly to attract mate and to provide for the youngs with food. The females would choose males that either have larger territories or have territories with abundant resources (Temeles & Kress 2010). Moreover, an important factor in maintaining the territories is that the conspecifics will not interfere with the breeding activities of the territory owner. These disturbances may range from minor distractions to stealing of the nesting materials, and may range to reduction of breeding success and even failure altogehter (Pruett-Jones & Pruett-Jones 1994; Krebs 1998). Such examples are, the stealing of nesting material in bowbirds and breaking of the eggs in the neighbouring nests by marsh and house wrens, and crimson rosellas (Pruett-Jones & Pruett-Jones 1994; Krebs 1998). The nest destruction, if not defended may reach upto 40% as compared to about 5% in defended nests in some species such as Green-rumpled parrotlet (*Forpus passerinus*) (Beissinger et al. 1998).

Nest construction is one of the attributes given to birds. Nests play an integral role in the breeding success of most of the bird species. They provide safe haven to both parents, eggs and hatchlings, and they help to regulate temperatures during the incubation period. Some species such as humming birds construct their nests in a way to conserve heat during the night times when temperatures are considerably low (Calder 1973). The birds in desert habitats tend to construct their nests in shades or conceal them in a way that the high desert temperatures do not negatively impact the breeding success of these birds (Winnett-Murray 1980). The birds construct their nests in a number of ways, according to the best possible survival strategies that the birds have acquired over the course of evolution. These include the camoflague of the nest with materials that blend in to the surrounding environment, structure of the nest to provide concealment, and location of the nest making it inaccessible to the predators. Moreover, some birds such as parrots, kingfishers, and torgans select the nesting sites near other animals that are not harmful for them but deter their predators such as termites, ants, wasps etc. (Young et al. 1990; Joyce 1993). Furthermore, some species construct their nests at the tips of thing and swinging branches in a manner that the structure of the nest provides protection to the eggs from falling out and the location of the nest at thing branches deters the predators such as monkeys from reaching to the nests. Moreover, the nest location in terms of the foraging behaviour fo the species is also of special consideration.

Most of the species construct their nest within the close proximity of their foraging grounds. However, there are some exceptions to this behaviour such as in secretary birds (*Sagittarius serpentarius*) that spends its time on ground but constructs its nest on the top of small trees. However, on the other hand, some species change their nesting sites according to the seasonal variations or other factors such as presence or absence of predators. For example, opreys (*Pandion haliaetus*) prefer to construct their nests on the top of trees. However, they also make nests on ground if there are no predators or no trees available (Tieleman et al. 2008). Birds also select their nesting sites where they have low inter and intraspecific competition, and risk of predation. Even minor disturbances from humans such as researchers observing nests may cause the birds to abandon their nesting site at early stage of the breeding period (Winkler 2016).

The role of sexes in nest construction varies among the species and their mating behaviour. Generally, in the species where females select the mate, males are responsible for nest construction. Whereas, in species where males select the mate, nest construction is by the females. However, in some species, both the sexes equally contribute in nest building as they bond with each other at earlier phases of mating. Another important factor that determines the contribution of sexes in nest construction is the sexual dimorphism. In species, where males are brightly coloured the females are the ones that construct the nest. It is an adaptation to avoid detection of the nest by predators as females are dull coloured and are not easily detectible (Winkler 2016). Moreover, the time taken to construct a nest also depends on the type of nest that a given species prefers to construct along with some other factors such as time of the breeding season, climatic conditions, etc. The time of nest construction may range from a week over to nearly a month (Wilson & Wilson 1986).

Birds are the only class of order Chordata that do not have any live-bearing species and exclusively lay external eggs. It might be an evolutionary adaptation to increase the breeding success as live-bearing may reduce the number of off-springs per breeding season, and a chance to abandon the eggs in case the conditions to incubate the eggs are not suitable. The egg size is larger in larger species such as ostrich. However, if we compare the egg size to the body weight of adult bird, the egg size of ostrich is much smaller (only 1.7%). Moreover, the birds that have larger clutch size, lay small-sized eggs as compared to the species that lay larger eggs. Similarly, the egg size varies depending on the condition of the hatchling whether it is precocial or altricial. The size of the eggs where chicks are precocial is larger compared to the similar sized species where the chicks are altricial (Winkler 2016).

The egg shape is directly related to the size of oviduct and its contraction. Some species lay nearly spherical eggs, while others lay pear-shaped eggs. The shape and colour of the eggs help the eggs to stay in the nest and well concealed from the predators. Egg colouration is one of the advantages to protect them from the predators. However, it may be metabolically expensive to produce those markings and colouration (Lahti & Lahti 2002). The duration of egg laying differs in different species depending on the size of the birds, size of the eggs, clutch size, food intake and its nature. Some species like small galliforms may lay one egg every day, while larger birds or birds with large egg size such as ostrich may lay egg every alternating day. Perhaps it is to give the oviduct sufficient time to secrete the layers oround the ovum (Winkler 2016).

Antoher important element of the breeding biology of the birds is the clutch size. The clutch size may be defined as the number of eggs a female lays during one nesting period. Studying variations in the clutch sizes provide an important insight to the life histories of the birds. As a general rule, the species that are closely related, tend to have similar clutch sizes e.g. seabirds lay one egg, shorebirds lay upto four eggs, and passerines usually lay approximately 2-6 eggs. An important and critical factor that limits the clutch size is the food availability. As laying an egg has high metabolic expenditure and toll on the females, if the food is scarce, the clutch size is reduced (Winkler 2016).

As the birds lay eggs externally, these eggs need to be kept in a suitable temperature range as they develop until hatching. Usually this range is between 37-38 °C. However, it is not possible as the environmental temperatures may either differ from the desired optimal temperature or ther might be temperature variations during day and night times. This optimum temperature is maintained by the parents by actively incubating the eggs. The duration from the start of incubation until hatching of the chicks is called incubation period. The incubation period also various among species and may range from approximately 11 days in finches to 80 days in albatrosses. The incubation period may also vary within a species and even within the same colony. When the chicks hatch, the birds get their clue to shift their efforts from incubation to the rearing of the hatchlings. Without this clue the birds may keep incubating inviable eggs as much as three times to that of the normal incubation periods e.g. Northern bobwhites (*Colinus virginianus*). Although, both sexes contribute in incubation process in many species, various species have different strategy for incubation. For example, in many passerines, geese, ducks, etc. the females are responsible for incubation and the males defend the territory and provide food to the incubating female (Winkler 2016).

The hatchlings are mainly categories into two groups depending on their developmental stage to cope up with the external environment. These two are altricial (without any feathers and weak thermoregulatory system and complete dependence on parents for food) and prococial (fully matured with feathers, can run, and are somewhat independent of parents for feeding) (Starck & Ricklefs 1998). The prococial hatchlings usually leave the nest shortly after they hatch and stay with their parents until they are able to fly by themselves. During this period the parents protect them and provide them with food and train them to find the food by themselves. However, the altricial youngs stay longer in the safety fo the nests and wait for their parents to feed them and leave the nests until they are able to fly. Some species such as predators may also teach their youngs how to capture their prey such as harriers, kestrel, kingfishers, etc. (Winkler 2016).

Common kestrel (*Falco tinnunculus*) belongs to family Falconidae and is listed as Least Concern (LC) in Red List of Threatened Species by IUCN (BirdLife-International 2016). In the United Arab Emirates (UAE) it is winter visitor and passage migrant with some resident populations (Aspinall et al. 2011). Common kestrel prefers mountainous and rocky areas but is also found in deserts, forests, farmlands, towns and gardens (Aspinall et al. 2011; Anushiravani & Roshan 2017a). The breeding pairs usually select cliff, tree cavities, crags, poles, artificial nesting boxes or sometimes building structures; they are also known to usurp nests from other species (Hustler 1983; Anushiravani & Roshan 2017a). The reported start of the courtship and nest selection is late March, and egg laying starts between late April and early May with an average clutch size of 3-6 eggs (Massemin et al. 2002; Valkama et al. 2002). The incubation in common kestrel is reported to be between 27-31 days; and the average fledging period is 27-39 days (Valkama et al. 2002; Anushiravani & Roshan 2017a).

Saunders's Tern (*Sternula saundersi*) is listed as Least Concern (LC) by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (BirdLife-International 2016b). It is a small bird that is marginally larger than a swift and has a black bill, outer primaries and head. *I*n breeding plumage, the species has a yellow bill that ends in a black tip and develops a white triangular forehead patch (Aspinall et al. 2011). Saunders's Tern is native to the United Arab Emirates (UAE), Yemen, Tanzania, Sudan, Somalia, Sri Lanka, Saudi Arabia, Qatar, Pakistan, Oman, Maldives, Kuwait, Kenya, Bahrain, India, and Madagascar (BirdLife-International 2016b). In the UAE, it is a summer and autumn visitor along the eastern coast (Aspinall et al. 2011), and in particular, a summer breeder at Sir Bani Yas Island, where it breeds on the northern and eastern coastline. Saunders's Tern spends winters outside its breeding range (Burger & Gochfeld 1996). Although the species is poorly studied, the significant threats that have been reported for Saunders's Tern include predation and anthropogenic factors (Burger & Gochfeld 1996).

Saunders's Tern usually breeds in non-social pairs or may breed in small, loose colonies that range from five to thirty pairs (Burger & Gochfeld 1996). The nests have been recorded up to two *kilometers* inland and are usually small depressions on the bare surface of sand or dried mud. The preferred nesting sites are sand mounds near vegetation (Burger & Gochfeld 1996). The neighboring nests are approximately 20 to 100 meters within these loose colonies. The nests lack any isolation materials, e.g. twigs, grass, and feathers, or cover and are entirely exposed to extreme environmental and ecological stressors. The breeding season usually lasts from March to June, during which both male and female partners participate in the incubation of the eggs (Burger & Gochfeld 1996; Shobrak & Aloufi 2014; AlRashidi & Shobrak 2015).

The Osprey (*Pandion haliaetus*) has a cosmopolitan distribution and it is a not rare breeder in some coastal areas in the United Arab Emirates, Bahrain, and Oman in the Arabian Gulf region (Khan et al. 2008; Jennings 2010). The species is pre-dominantly a ground nester in Arabia, but it also takes advantage of human-made con-structions such as abandoned buildings or electricity pylons (Jennings 2010). Artificial nesting platforms have been installed in the United Arab Emirates to aid reproduction and to overcome a lack of a sufficient number of suitable nesting sites. Nest platforms are known to have a positive effect on the breeding productivity of ospreys and other raptors (Brown & Collopy 2008; Hunt et al. 2013). The current study therefore com-pares the breeding success of a small population of ospreys on the mainland and on the neighbouring island and evaluates the efficency of artificial nesting platforms which have been established to enhance breeding success.

Chapter 4

MOSAIC OF NATIVE AND MAN-MODIFIED MANAGED ENVIRONMENTS SUPPORTS THE AVIAN SPECIES DIVERSITY AND COMMUNITY STRUCTURE ON DESERT OFF-SHORE ISLAND IN THE ARABIAN GULF

Adopted from: Kabeer B, Mehmood A, Hejcmanová P. Mosaic of Native and Man-modified Managed Environments Supports the Avian Species Diversity and Community Structure on Desert Off-shore Island in the Arabian Gulf. Submitted.

Introduction

The avifauna in the ecosystem has vital functions in various ecological niches and birds are important indicators reflecting the condition of habitats (Veeramani & Usha 2018). Birds' contribution in maintaining ecological health can range from controlling the populations of pest insects and rodents, scavenging on carcasses, to impacts on vegetation, for instance by seed dispersal (Gatesire et al. 2015). The response of birds is rapid to variations in the function, composition and landscape of habitats (Turner 2003; Sidra & Chaudhry 2013).

Birds in hot arid ecosystems are particularly vulnerable due to changing rainfall patterns, unpredictable droughts, and intense heat waves (Zhou et al. 2015) curtailing their water and food resources (Bohning-Gaese & Lemoine 2004). The resilience of desert avifaunal communities is thereby compromised and at risk of sublethal fitness impacts constraining birds' survival and reproduction (Iknayan & Beissinger 2018; Conradie et al. 2019). There is therefore a need to identify and assess potential mitigation measures to defeat these risks.

A possible approach, commonly practiced around the world, can be an artificial modification of habitats and landscape, for instance by afforestation with an intensive habitat management (Lambin & Geist 2006). The initial purpose of intensive habitat management can be commercial for timber production, soil conservation, to improve degraded or disturbed habitats, or covering barren land to improve carbon sequestration and climate, and fighting desertification (Bremer & Farley 2010). It has both positive and negative implications on bird communities, depending on its purpose, the previous condition of the area and the type of plantation, i.e. monoculture or polyculture, including plant species whether it is native or exotic (Graham et al. 2017). If natural forest cover is replaced by non-native plant species, for instance for commercial benefits, such management practices foster shifts in bird community composition and diversity, often loosing original native site-specific, i.e. endemic, species (Maestre & Cortina 2004). On the other hand, if a disturbed habitat or area where there was previously no vegetation is intensively managed and restored, resulting habitats may provide new refugia, create a hub of local biodiversity (Bremer & Farley 2010; Rittenhouse et al. 2012; Frey et al. 2016), and fulfil new ecosystem functions and services.

The Sir Bani Yas Island (hereafter as SBYI) is a small (8,700 ha), yet the largest natural island in the Emirate of Abu Dhabi, UAE, that belongs to desert ecoregion surrounding the Arabian Gulf. The SBYI was declared a wildlife reserve in 1971, yet the island was barren and unoccupied with no confirmed reports of existing fauna. In January 1980, only nine bird species in total, among which pointing out only one individual of white-fronted goose, were reported (Dome Oilfield Engineering & Services LLC 2009). Since that time the SBYI went through a lot of ecological modifications, with plantation of approximately two million trees, artificial irrigated pastures and bringing an endangered wildlife, mostly large herbivores, for conservation under intensive breeding management (Mehmood et al. 2014). It created an interesting mosaic of natural desert, coastal and green artificial habitats. Then, the island started welcoming birds and the SBYI thus appeared to fulfil secondary ecosystem functions.

To assess the effects of land modifications in the desert ecoregion of Arabian Gulf and surroundings, we investigated the avifauna, their community spatiotemporal dynamics in native and artificial (afforested and irrigated), intensively managed habitats on the desert offshore Sir Bani Yas Island (SBYI) in the UAE. Specifically, we investigated 1) which bird species inhabit the SBYI, their feeding guild, migratory and conservation status; 2) the seasonal and inter-annual dynamics of the species richness, species diversity and equitability in bird communities in natural desert and coastal, and artificial, intensively managed habitats; and 3) the bird community structure, species mutual relationships and species co-occurrence in habitats on the island.

METHODS

Study Site

The Sir Bani Yas Island is an off-shore island in the western region of Abu Dhabi (Figure 1). The island receives an annual rainfall of 150 mm per year with average temperatures ranging between 18°C in January and 35°C in July and August (Mehmood et al. 2014).

Due to intensive habitat management during last thirty-five years, the island now has various plant species such as Vachellia tortilis, Aizoon canariense, Anethum graveolens, Arnebia hispidissima, Conocarpus didymus, Heliotropium bacciferum, Melilotus indicus, Phoenix dactylifera, Phyla nodiflora, Phyllanthus maderaspatensis, Prosopis juliflora, Sesuvium portulacastrum, Solanum nigrum, Solanum xanthocarpum, Sporobolus spicatus, Ziziphus spina-christi, and Zygophyllum simplex. There are currently 18 ungulate species (among others gazelles, deer, oryx, giraffe, llama, and eland) in a total number of approximately 16000 individuals, then four carnivore species (cheetah, hyaena, jackal, and caracal), and three ratite species (ostrich, emu, and rhea), on the island, all for conservation as in an intensively managed ex-situ breeding facility.

There were four major habitat types, i.e. coastal area and mountain as natural habitats without management interventions, and irrigated planted forest and pastures as artificial habitats (Figure1). The coastal area was characterised by coral and seashell shingle sandy beaches dominated by mangrove species i.e. *Avicennia marina* and *Rhizophora mucronata*. Mountains covered the central part of the island characterised by natural outcrops of various types of rocks with an elevation range between 70-130 meters. The planted forest area was characterised by forest blocks of various tree and shrub species, irrigated through drip irrigation, and pastures on the island were predominantly seeded by *Cynodon spp*. (Dome Oilfield Engineering & Services LLC 2009; Mehmood et al. 2014).

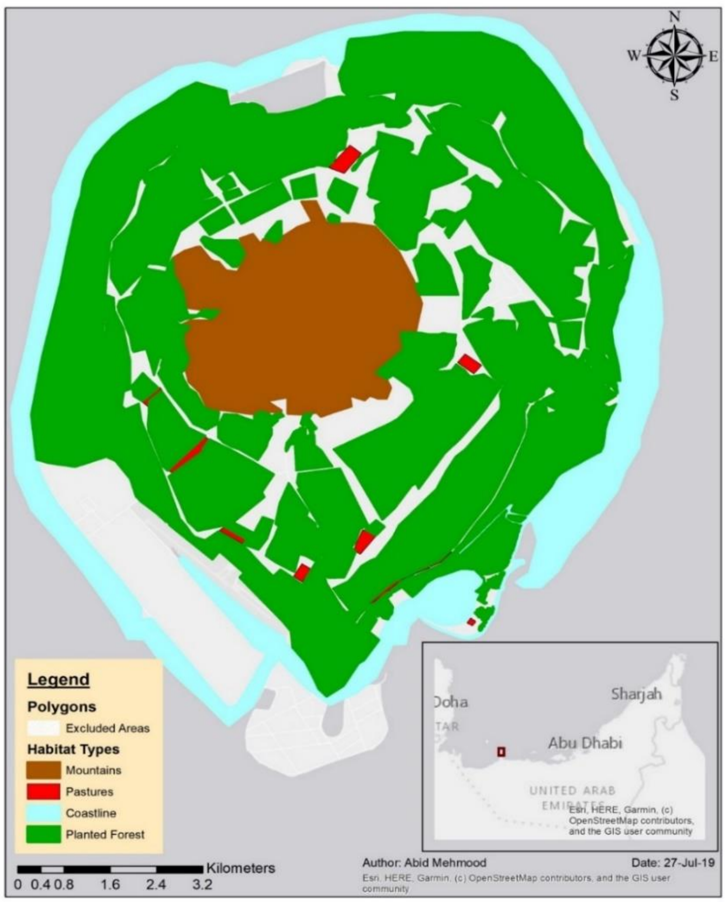


Figure 1. Spatial distribution and land coverage of habitat types at the Sir Bani Yas Island, United Arabian Emirates.

Data Collection

The data were collected in all four habitat types in a stratified random sampling design from January 2014 to December 2018. A grid of 1 × 1 km was laid over the study area, two cells were selected at random in each habitat type (Tucker et al. 2005), and a transect of fixed length and width of 800 meters and 100 meters, respectively, was laid there. All the birds, i.e. species and number of individuals, were recorded within the transect area. Each transect was visited once a month with a total of sixty surveys per transect during five year study period (Anwar et al. 2015). The bird species were identified and taxonomically classified using the field bird guide (Aspinall et al. 2011). The conservation status was extracted from IUCN Red List for all species. The species were also categorised in terms of their feeding guilds according to their feeding habits such as carnivorous, frugivorous, insectivorous, granivorous, nectivorous, and omnivorous (Gatesire et al. 2015).

Data Analyses

Records of the number of species and number of individiuals of each species on transects sampled once a month during the period of 5 years were independent measurement (statistical) unit. For each record, the Shannon-Wiener index considered as index of species diversity and equitability in communities (Tucker 2005) was calculated using the formula:

$$H = -\sum_{i=1}^{S} p_i \ln p_i \qquad p_i = \frac{n_i}{N}$$

where S is the total number of species, n_i je is the number of individuals of i-species, N is the total number of individuals, and p_i is the relative representation of i-species on the sampling plot.

Then, we tested the data on species richness (number of species per transect) and species diversity (Shannon-Wiener index) for normality, using the Kolmogorov-Smirnov test. To test the differences of species richness and diversity (these two as separate dependent variables) among habitats, years, months and interactions ‘habitat*years’ and ‘habitat*month’ (these as categorical predictors), we applied two separate general linear models in the Statistica 13 package (TIBCO Software Inc., Palo Alto, USA). In case of significant differences, the post-hoc HSD Tukey tests were performed to identify where these differences were.

Bird Community Structure and Species Co-Occurrence Model

To examine the mutual relationships of species in bird communities at the SBYI and in separate habitats, we used the multivariate constrained Redundancy Analysis (RDA) in the Canoco 5 package (Ter Braak & Šmilauer 2012). First, we tested effects of habitats and time of the year (months), as explanatory variables, on bird species community at the whole SBYI in two separate analyses, one based on bird species, second based on functional groups of feeding guilds. Then, we tested the effect of the of the year (months) for each habitat separately. The dependent variables were data on number of each species at one independent sampling event. The data were log-transformed and standardized in all analyses. To test the significance of our constrained ordination model, unrestricted Monte Carlo permutation tests (permutations n=999) were applied. Results of the analyses were visualised in the form of ordination diagrams.

To get complementary insight into bird community structure, we performed the probabilistic analysis applying the pairwise approach comparing species co-occurrence on the SBYI and in each habitat separately during sampling events. The approach consists in comparison of observed species pairs to the distribution expected and in testing if the species were distributed independently from each other (Veech 2013). These models quantify pairwise associations between species as random or significantly non-random plus whether the significant association is higher or lower than the expected value. We tested the co-occurrence between species pairs (for 156 out of total 164 bird species), using the sampled datasets in form of presence – absence. The probabilistic models were generated with the package "cooccur" in R (Griffith et al. 2014). Heat maps were generated from the models to visualize the species pairwise associations as negative, random, and positive.

RESULTS

A total of 164 species were recorded on the SBYI island belonging to 46 families from 19 orders (Table 1). The highest number of species were recorded from the order Passeriformes (38.4 % of all species), followed by Charadriiformes (29.2 % of all species). The most abundant species in terms of individuals was slender-billed gull, followed by other gull and tern species, and several dove species in the first top ten (Figure 2). The terns and gulls migrated in to the island in large flocks and usually occupied northern side of the island.

Out of the recorded species on the SBYI island 84.1 % were migratory and 15.9 % were resident on the island. According to the IUCN Redlist of threatened species, 95.7 % species belonged to least concerned category, whereas, 1.2 % each belonged to near threatened status and 0.7% were not assessed yet. However, 2.4 % species were listed as 'Vulnerable category of threatened species that might be at risk of extinction in future, namely eastern imperial eagle, greater spotted eagle, houbara bustard, and Socotra cormorant. The birds were categorised into seven feeding guilds. The highest number of species were insectivorous (35.8 %), followed by carnivorous (25.7 %), grainivorous (17.3 %), omnivorous (15.9 %), frugivorous (4.4 %), piscivorous (0.4 %), and nectivorous (0.4 %) (Figure 3).

Table 1: The richness of birds' orders, families, genera and species at Sir Bani Yas Island, United Arab Emirates.The richness of birds' orders, families, genera and species at Sir Bani Yas Island, United Arab Emirates.

Order	No. of Families	% of Family	No. of Species	% of Species
Accipitriformes	2	4.35	8	4.88
Anseriformes	1	2.17	3	1.83
Apodiformes	1	2.17	1	0.61
Bucerotiformes	1	2.17	1	0.61
Caprimulgiformes	1	2.17	1	0.61
Charadriiformes	7	15.22	48	29.27
Columbiformes	1	2.17	5	3.05
Coraciiformes	3	6.52	4	2.44
Falconiformes	1	2.17	4	2.44
Galliformes	2	4.35	7	4.27
Gruiformes	2	4.35	3	1.83
Otidiformes	1	2.17	1	0.61
Passeriformes	17	36.96	63	38.41
Pelecaniformes	1	2.17	9	5.49
Phoenicopteriformes	1	2.17	1	0.61
Psittaciformes	1	2.17	1	0.61
Pteroclidiformes	1	2.17	1	0.61
Strigiformes	1	2.17	1	0.61
Suliformes	1	2.17	2	1.22
Total	**46**	**100.00**	**164**	**100.00**

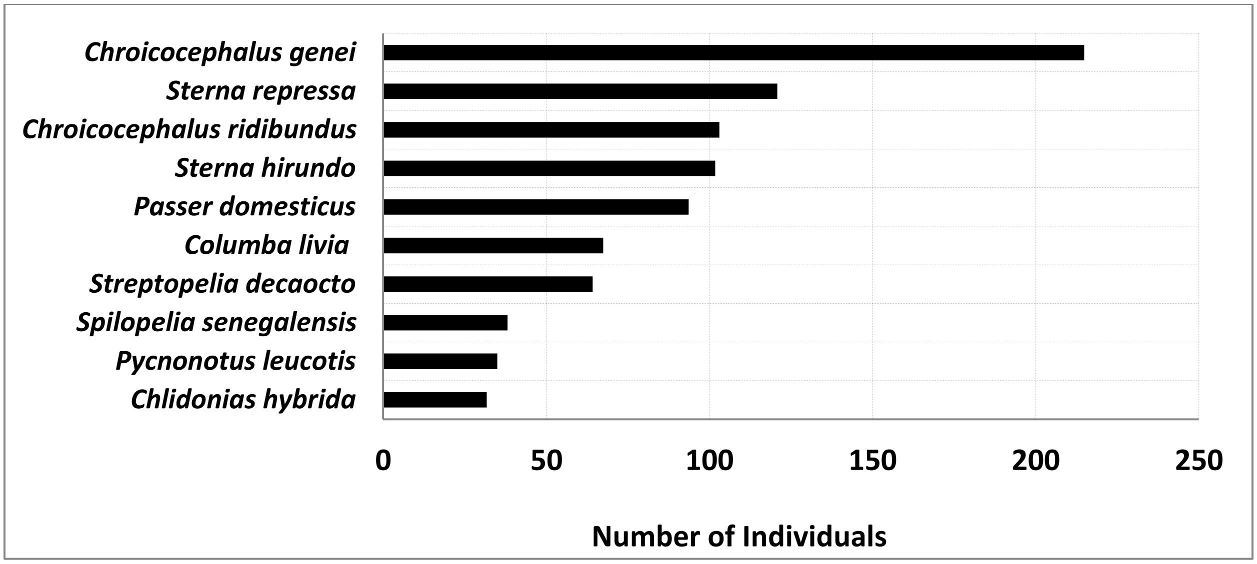


Figure 2. Top ten abundant species (average individuals from 2014-2018) in all habitat types on the Sir Bani Yas Island, United Arab Emirates.

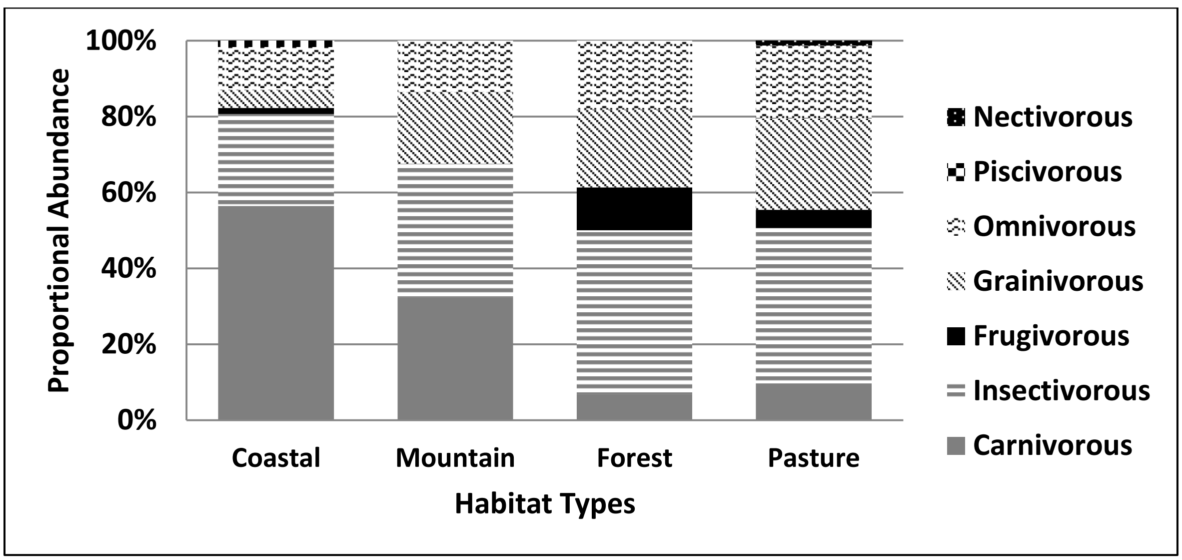


Figure 3. Proportional abundance of the seven dietary guilds observed in four habitat types on Sir Bani Yas Island, United Arab Emirates

Spatiotemporal Species Richness and Diversity

The species richness significantly differed among habitats (F = 281, DF = 3, $P < 0.001$), hosting the highest number of species on pastures (mean± SE; 40.1 ± 1.4 species), followed by significantly lower numbers in coastal habitat (31.5 ± 0.7 species) and the two lowest numbers of species were recorded in forest (22.0 ± 0.7 species) and mountain habitats (21.3 ± 0.6 species). The species diversity index was significantly higher on pastures (3.0 ± 0.03) than in forest (2.4 ± 0.02) and mountain (2.4 ± 0.03) habitats and significantly lowest diversity on the coast (2.1 ± 0.06) (F = 111, DF = 3, $P < 0.001$).

There was pronounced seasonal dynamics in both, the species richness and diversity, with the high values in the colder period of the year from November till March, then decreasing and culminating low values between June and August, the warmest period of the year, showing the similar pattern for all habitats (Figure 4). There were no important inter-annual changes of species richness and diversity on the whole SBYI, neither in particular habitats, with the exception of a drop of species richness on pastures and on the coast between 2014 and 2015 (Figure 4).

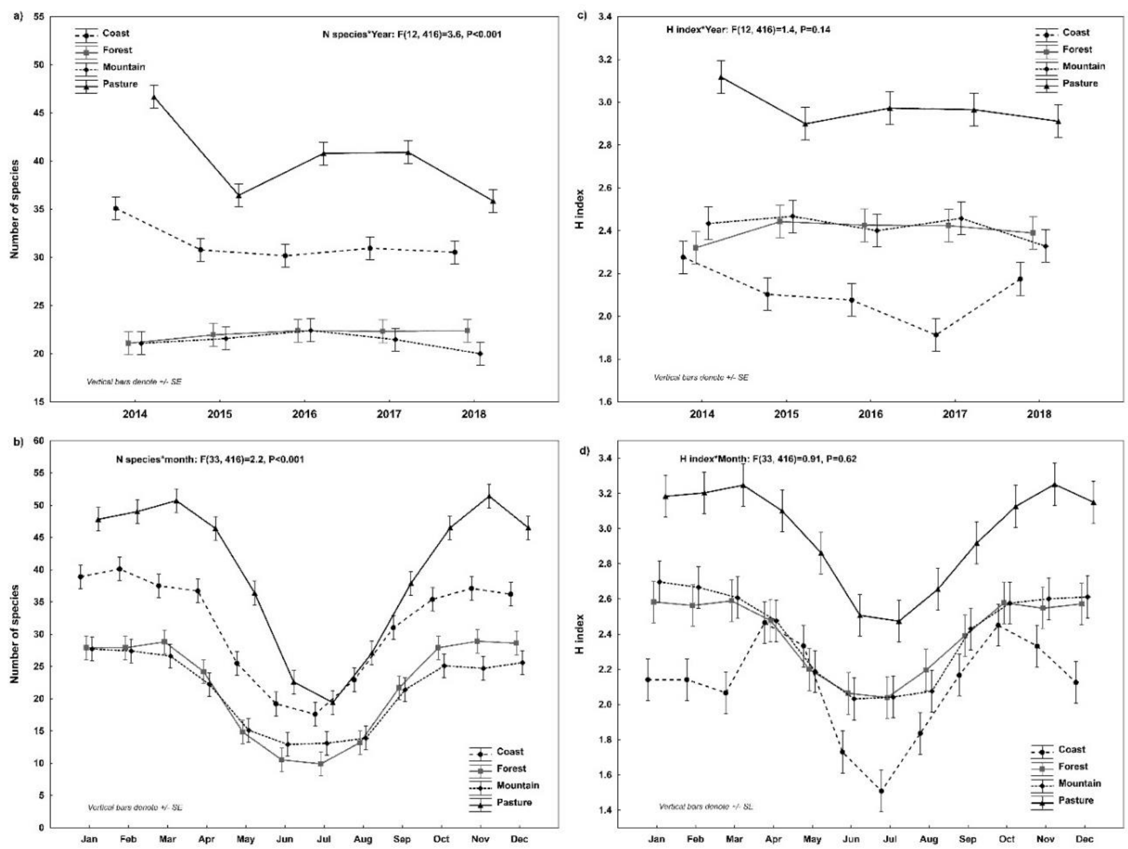


Figure 4. Bird species richness and diversity between 2014 and 2018 and in the course of the year at the Sir Bani Yas Island, United Arabian Emirates.

The functional diversity of bird communities, tested by the RDA, was primarily driven by habitats, then by season (Table 2) and explained altogether 62.8 % of the variability in the data. Specifically, the first (x) axis of the ordination diagram represented the carnivorous (including piscivorous) birds related to the coast habitat on one side and the granivorous birds related to the afforested area on the other side. The second axis represented the contrast between highly diverse communities on pastures hosting a range of feeding guilds and the mountain area where no specific feeding guild is related to. The seasonal variation is linked to the second axis pointing out the relation of hot months (May – August) to direction of least diversity, similar to mountain habitat, while less hot months (October – April) were positioned in the middle of the diagram which means that the functional diversity of birds in this period of the year is high in all other habitats (Figure 5).

Bird Communities and Species Co-Occurrence

Regarding the bird species in communities at the SBYI, the multivariate RDA showed significant effects of habitats and time of the year at the island and explained 40 % of the variability in the data, whereas there were significant effects of the time of year on the bird species community within each habitat separately explaining around one third of variability in data (Table 2). The bird species composition on the island was distinguished primarily by habitats, then by the time of the year. Specifically, the first (x) axis of the ordination diagram represented the species related to the coast habitat. There were three species negatively related to the coast habitat, namely *Columba livia*, and *Streptopelia decaocto*. That were related to forest habitat, and *Passer domesticus*. The second axis represented the time of the year (months), the habitat of mountain, and slightly the habitat of pasture with species *Francolinus pondicerianus* and *Vanellus indicus* (Figure 5). The complementary species pairs co-occurrence analysis showed that 88.6% of species pairs co-occurred non-randomly (Table 3).

Table 2. Explained variability in bird species community datasets and effects of external variables, i.e. habitats and time of the year for whole Sir Bani Yas Island and time of the year for habitats separately, using multivariate RDA analysis.

	Explained variability (in %)			**F and P-value of tests**	
Site / Habitat	**First axis**	**Second axis**	**All (4) axes**	**First axis**	**All (four) axes**
Island – feeding guilds	42.2	16.5	62.8	F=23.2; P=0.001	F=56.1; P=0.001
Island – bird species	19..6	10.3	40.0	8.1; P=0.001	F=24.2, P=0.001
Coast	21.5	4.2	31.0	F=2.7, P=0.001	F=5.6, P=0.001
Mountain	18.2	2.5	24.2	F=2.2, P=0.001	F=3.6, P=0.001
Forest	22.3	3.3	29.6	F=2.8, P=0.001	F=5.0, P=0.001
Pasture	16.4	4.0	24.3	F=1.9, P=0.001	F=4.2, P=0.001

Table 3. Summary of the probabilistic model results for positive, negative, and random pairwise species co-occurrence for datasets of the whole island and separate habitats.

	SBYI island	**Coast**	**Mountain**	**Forest**	**Pasture**
Number of species	156	62	37	41	81
Sampling events	480	120	120	120	120
Species-pair combinations*	10021	1699	552	820	3099
Positive co-occurrence	3977	433	161	325	1224
Negative co-occurrence	4906	203	5	38	114
Random co-occurrence	1138	1063	386	457	1761
Non-random (%)	**88.6**	**37.4**	**30.1**	**44.3**	**43.2**

* pair-combinations analysed, pairs with expected co-occurrence < 1 were removed from the analysis

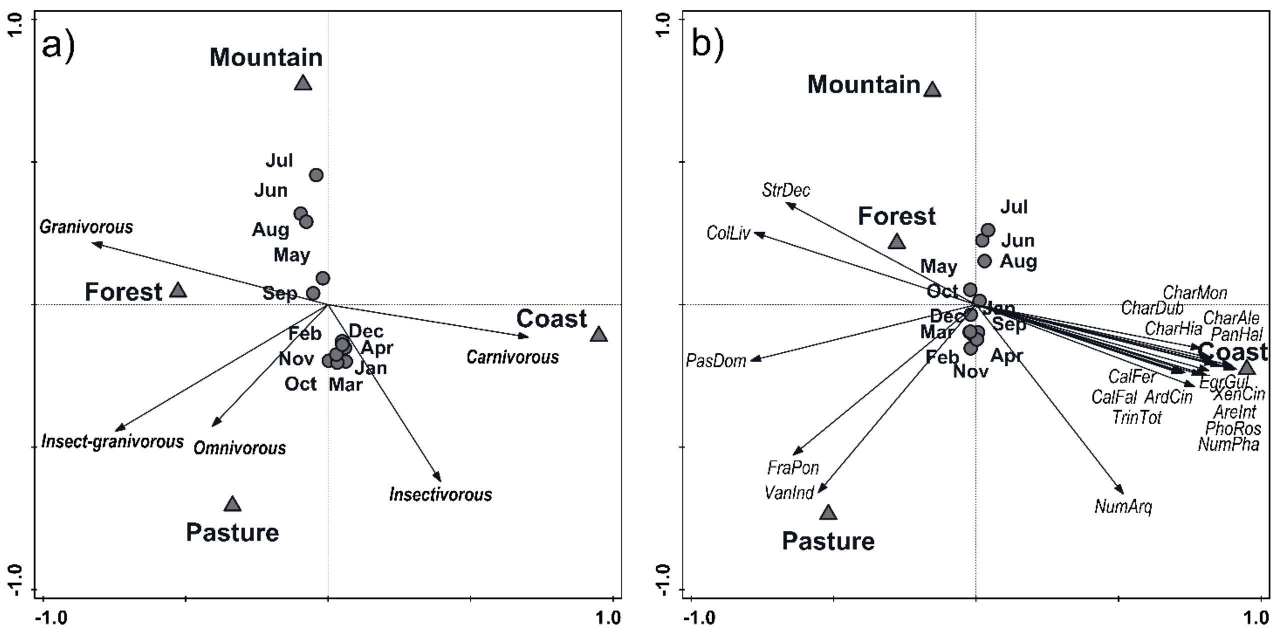


Figure 5. RDA ordination diagrams of the first two axes of the a) feeding guilds, and b) bird species, both based on abundance data at the Sir Bani Yas Island, United Arabian Emirates, between 2014 and 2018. Habitats are labelled by triangles and month of the year by circles. Twenty bird species with the highest fit to the axes are displayed.

The bird communities showed the same pattern in all habitats which was the strong negative relationship of bird communities to hot dry season, specifically in June, July, and August contrasting mostly to November associated to important amount of bird species with highest fit, as showed by the first (x) axis (Figure 6). In most habitats, the second axis represented the bird communities in September, however, this relation was very weak, not exceeding 5 % of explained variability (Table 2). There were, however, bird species associated specifically to the hot dry season in artificial habitats, namely *Coracias garrulus* on pasture and *Streptopelia turtur* in forest.

The results of species pairs co-occurrence analysis showed that most of species pairs had random associations in all habitats, while significant non-random species pairs associations ranged between 30% and 44%, most of which were positive (Table 3). The highest proportion of negative pairwise co-occurrences was found on the coast and on pasture where particularly *Coracias garrulus* showed negative co-occurrence with most of other species, while in forest and mountain, the proportion of negative co-occurrences was lower, however there was the same strikingly high negative co-occurrence of *Streptopelia turtur* with most of species in these habitats.

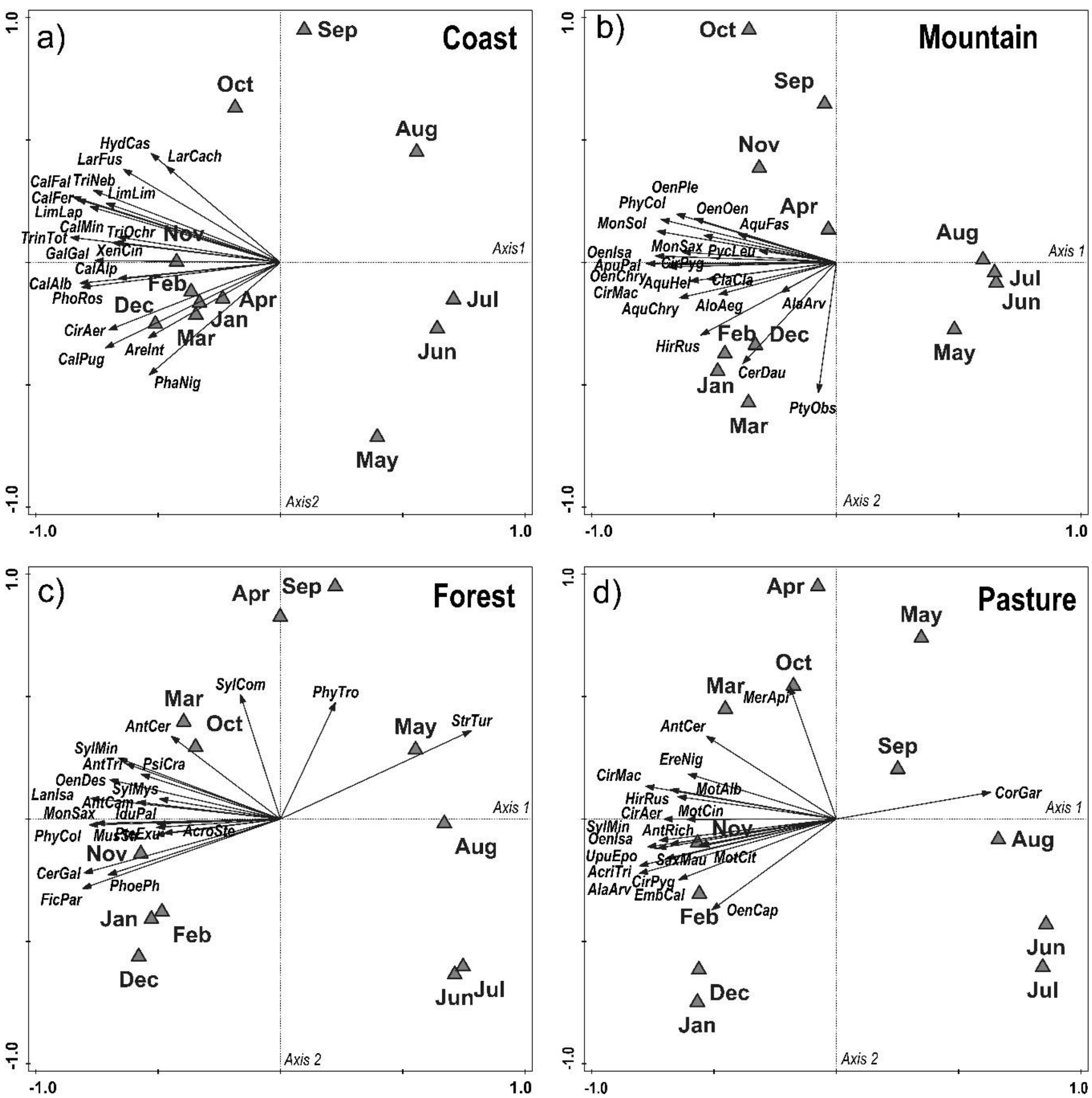


Figure 6. RDA ordination diagram of the first two axes of the bird bird species, based on abundance data, in four habitats at the Sir Bani Yas Island, United Arabian Emirates, between 2014 and 2018. Month of the year are labelled by triangles. Twenty bird species with the highest fit to the axes are displayed.

DISCUSSION

The current study, for the first time, described the bird community structure, co-occurence, spatial and temporal patterns on the intensively managed Sir Bani Yas Island in the UAE which is basically desert, yet intentionally transformed to a conservation center to harbour large endangered mammals. The significant number of recorded bird species (n=164) suggests that the management of island has succeeded to create suitable ecological settings to host such a vast number of species, particularly in comparison to nine species recorded before the extensive habitat mangement activities started about four decades ago (Dome Oilfield Engineering & Services LLC 2009). Majority of the species were migratory, which highlights that the geographical position of the island on long-distance migratory routes (Combreau et al. 2011) makes it an important stopover. For some species the island represented the only suitable breeding place even if at 8 km of distance from the mainland (Kabeer et al. 2020a, b; Khan et al. 2008), and for the Socotra cormorant, listed by the IUCN Red List as ‘Vulnerable’, it represents a breeding site of crucial conservation importance (Muzaffar 2020). Due to its location and new established habitats the island thus appears having become an effective stepping stone supporting the ecological connectivity within the surrounding desert ecosystems of the broader ecoregion of Arabian Peninsula and Arabian Gulf.

The species diversity and richness is dependent upon the vegetation type, habitat association and feeding guild of a given bird species (Ullah et al. 2020). Passerines, the most abundant and diverse taxon, associated to artificial intensively managed habitats, specifically pasture, while following abundant taxon, Charadriiformes inhabited mainly the coast, the original undisturbed habitat. A wide range of feeding guilds in bird communities, i.e. insectivorous, carnivorous, granivorous, and omnivorous as the most represented, proved that the island has the capacity to carry high functional diversity in the environment. The co-existence of natural and artificial habitats increased structural heterogeneity and enabled diversification of habitats which is clearly reflected in the relations of bird functional groups to specific habitats, and it is likely also for other various living organism such as invertebrates and smaller fauna (Felton et al. 2010) along with the diversity of fruits, grains and other plant food items (Cid & Caviedes-Vidal 2014), and thus the diversity of niches for birds.

Bird communities on the island showed coherence especially within the habitats where species co-occurred positively much more than negatively, i.e. mutually avoided. Multivariate analysis revealed specific importance of coastal bird communities at the island, contrasting to other habitats, despite lower species richness and diversity than found on pastures, but excelled by abundance of population of species. Among the habitats on the island, pastures appear to have become a keystone habitat hosting the highest species number and diversity despite its lowest area. Two ground species, grey francolin and red-wattled lapwing, represented the core of community at artificial pasture habitat, even if grey francolin did not inhabit it naturally, but was an introduced species to enhance the aesthetic functions of the SBYI. The multivariate analysis revealed other three species, which were related to the three land habitats, namely house sparrow, rock dove and Eurasian collared dove. These species are synanthropic and colonised the island likely due to the intensive management of the large herbivores in the wildlife reserve. They benefit from the fodder supplied to herbivores that comprise herbivore pellet feed and other grains.

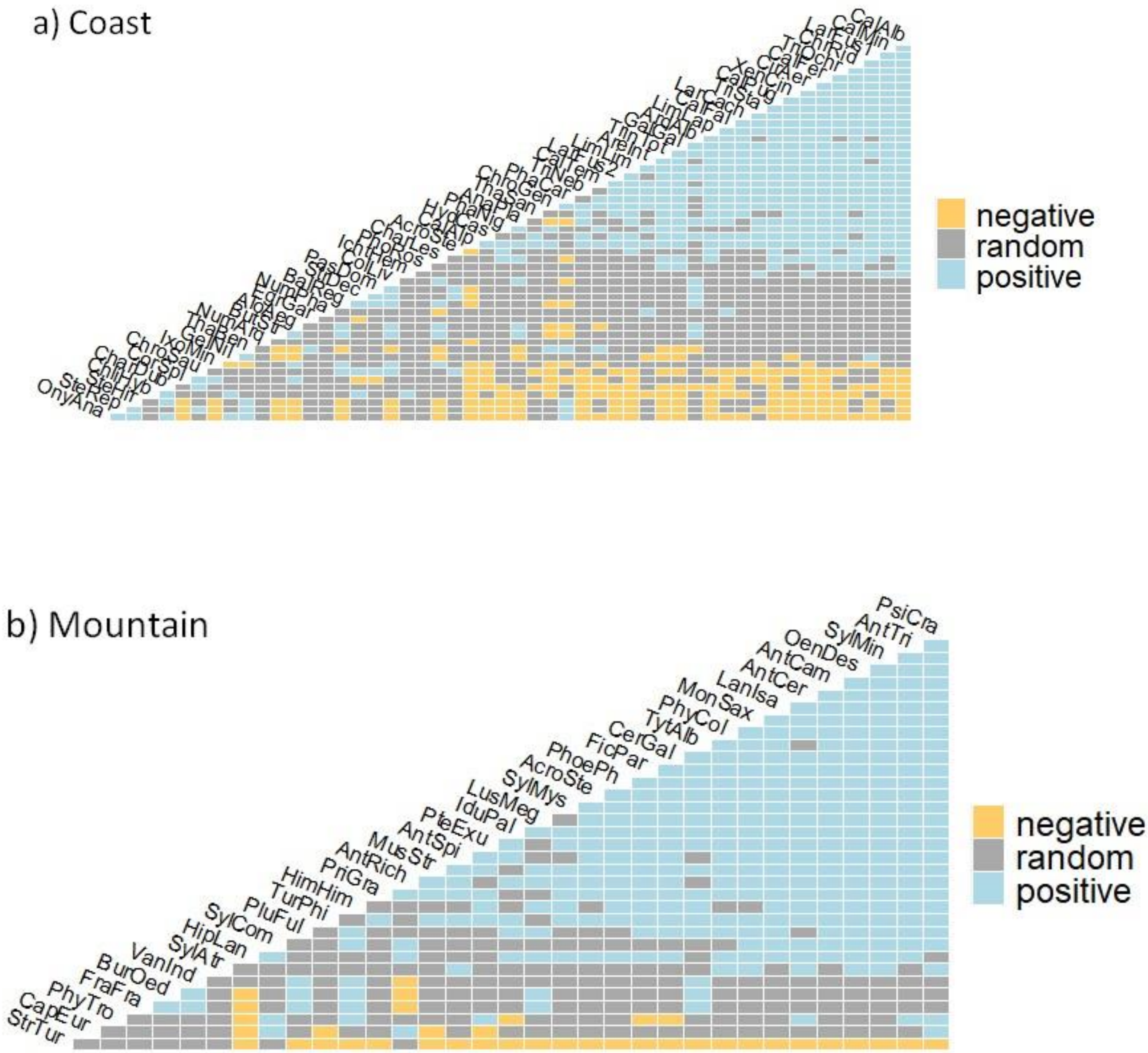
Besides habitats, the birds showed a clear temporal pattern following seasons, having peak of species richness and diversity in colder period between November and March and most of species leaving the island during the hottest months of the year, i.e. from June till August. This transformation of species richness and bird community was the most pronounced on pastures. This pattern confirms again that the SBYI Island hosts mostly migratory species as compared to the resident avian species, and its significant role as a bio corridor in the region. The island as a (private) protected area, provides a refuge for the seabirds which are globally declining (Paleczny et al. 2015) and supports key ecological processes such as successful reproductive performance (Muzaffar et al. 2012).

In the mountain area, natural habitat with no specific human-management, the species richness dropped the least which indicates that this native habitat hosts the species adapted naturally to desert. The habitats become virtually ‘empty’ during the hot season and gave opportunity to synanthropic species to take the space as they rely more on man-supplied food and water resources than on natural ones, especially European turtle dove in forest and mountain. It may have consequences on native communities as this species has the highest score for negative co-occurrence with other birds. On pasture, this role was taken by European roller even if not dependent on grains from herbivores’ fodder. They feed on insects and small vertebrates present on pastures artificially maintained by irrigation.

CONCLUSIONS

We may conclude that the intensive habitat management practices in desert regions can support the avian diversity. The ecological modifications (extensive vegetation management and irrigation) on the island coupled with protection of natural, unmanaged parts, i.e. mountains and coast, provide a mosaic of habitats and enhance ecosystem heterogeneity with the broader impact in the Arabian Gulf region. Bird communities serve there many functional roles, i.e. predators, pollinators, scavengers, and seed dispersers, thus fill their ecosystem function and ecosystem services.

Certain considerations should be paid to synanthropic species, which are supported not directly by extensive vegetation management, but by additional intensive management of large wildlife species, they consequently increase in abundance and demonstrate negative co-occurrence with other species.


a) Coast
negative
random
positive
b) Mountain
PsiCra
AntTri
SylMin
OenDes
AntCam
AntCer
LanIsa
MonSax
PhyCol
TytAlb
CerGal
FicPar
PhoePh
AcroSte
SylMys
LusMeg
IduPal
PteExu
AntSpi
MusStr
AntRich
PriGra
HimHim
TurPhi
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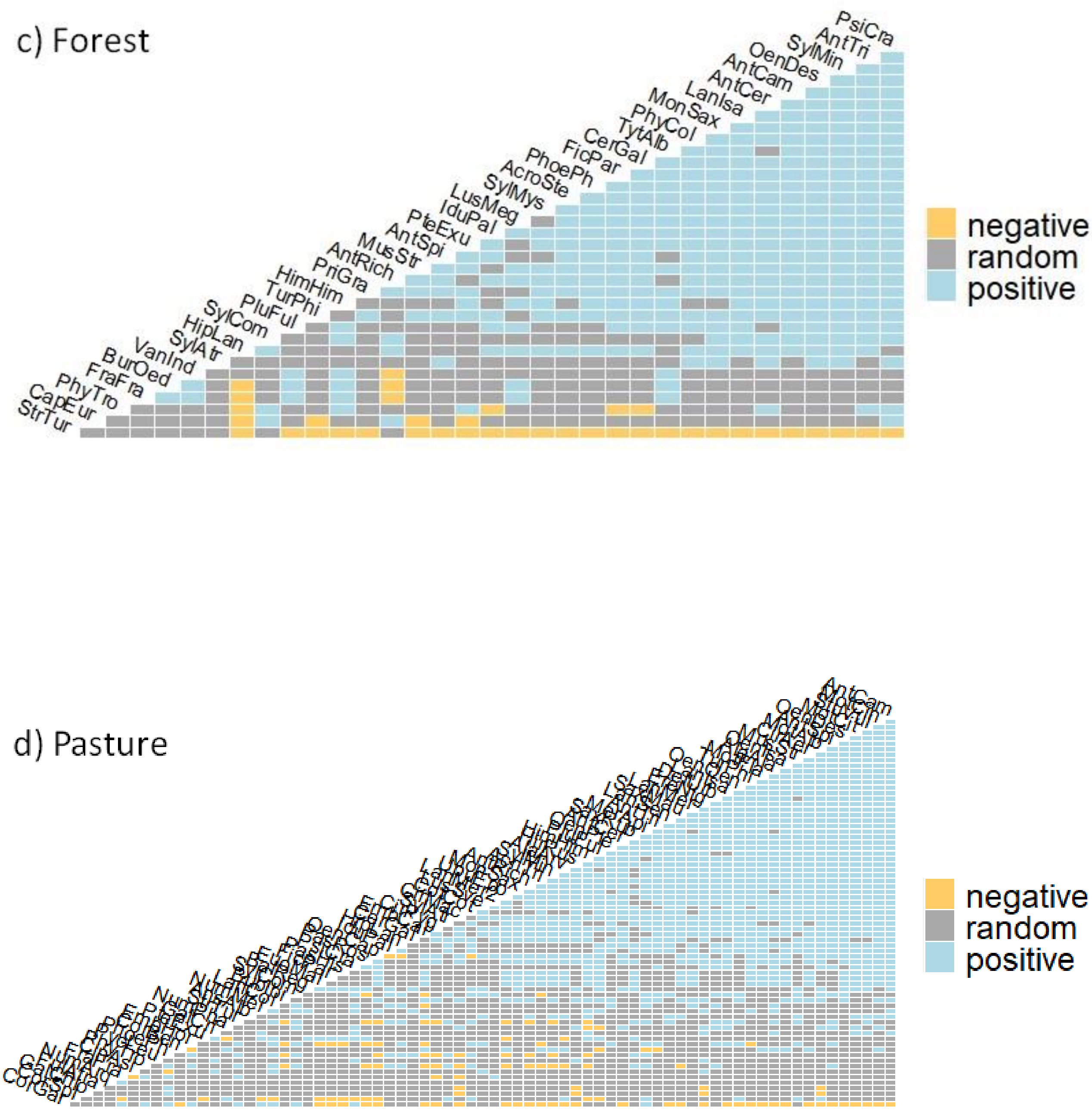

Figure 7. Heat maps of pairwise species co-occurrence in four habitats at the Sir Bani Yas Island, United Arabian Emirates: a) Coast, b) Mountain, c) Forest, and d) Pasture.

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BREEDING BEHAVIOUR AND THREATS TO SAUNDERS’S TERN (*STERNULA SAUNDERSI*) AT SIR BANI YAS ISLAND, UNITED ARAB EMIRATES

Adopted from: Kabeer B, Bilal S, Abid S, Hejcmanová P, Mehmood A, Asadi MA and Jilani MJ. Some aspects of breeding ecology and threats to Saunders’s tern (*Sternula saundersi*) at an offshore island of United Arab Emirates. Water Birds. (Accepted).

(Please refer to Appendix-III for accepted article)

INTRODUCTION

Saunders’s Tern (*Sternula saundersi*) is listed as Least Concern (LC) by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (BirdLife-International 2016b). It is a small bird that is marginally larger than a swift and has a black bill, outer primaries and head. In breeding plumage, the species has a yellow bill that ends in a black tip and develops a white triangular forehead patch (Aspinall et al. 2011). Saunders’s Tern is native to the United Arab Emirates (UAE), Yemen, Tanzania, Sudan, Somalia, Sri Lanka, Saudi Arabia, Qatar, Pakistan, Oman, Maldives, Kuwait, Kenya, Bahrain, India, and Madagascar (BirdLife-International 2016b). In the UAE, it is a summer and autumn visitor along the eastern coast (Aspinall et al. 2011), and in particular, a summer breeder at Sir Bani Yas Island, where it breeds on the northern and eastern coastline. Saunders’s Tern spends winters outside its breeding range (Burger & Gochfeld 1996). Although the species is poorly studied, the significant threats that have been reported for Saunders’s Tern include predation and anthropogenic factors (Burger & Gochfeld 1996).

Saunders’s Tern usually breeds in non-social pairs or may breed in small, loose colonies that range from five to thirty pairs (Burger & Gochfeld 1996). The nests have been recorded up to two kilometers inland and are usually small depressions on the bare surface of sand or dried mud. The preferred nesting sites are sand mounds near vegetation (Burger & Gochfeld 1996). The neighboring nests are approximately 20 to 100 meters within these loose colonies. The nests lack any isolation materials , e.g. twigs, grass, and feathers, or cover and are entirely exposed to extreme environmental and ecological stressors. The breeding season usually lasts from March to June, during which both male and female partners participate in the incubation of the eggs (Burger & Gochfeld 1996; Shobrak & Aloufi 2014; AlRashidi & Shobrak 2015).

Breeding success is critical for the maintenance of viable populations. Decreasing trends in the numbers of breeding pairs of Saunders's Tern have been documented globally every year (IUCN, 2018). Studies in Iran in the 1970s and in Bahrain from 1969 to 1981 suggested a substantial decrease in the numbers of breeding pairs (BirdLife-International 2016b). This study provides insight into the breeding ecology and threats to breeding pairs of the species, and we assessed the incubation routine, threats and the breeding success of Saunders's Tern on Sir Bani Yas Island, UAE.

MATERIALS AND METHODS

Study Area

Sir Bani Yas Island (24° 18' 41.04" N 52° 35' 45.24" E) is considered the largest natural island in the Emirate of Abu Dhabi, UAE. The island is located 180 km southwest of Abu Dhabi and 8 km offshore from the city of Ruwais. Sir Ban Yas Island has arid habitat types and a varied topography with small mountains, coastal habitats and mangroves. The coastal habitat is a mixture of intertidal mudflats, rocky shores, sandy beaches, and mangroves (Dhaheri et al. 2017b). The annual rainfall is 150 mm per year. It has a total area of 8700 hectares, including the 4100 ha Arabian Wildlife Park in the center of the island (Dhaheri et al. 2017a).

The primary breeding site was a one-kilometer coastal patch (a sandy flat, barren area next to beach) on the northern side of the island with a loose colony of an average of twelve to fifteen pairs. However, not all pairs exhibited courtship behaviours or constructed nests. The breeding site was characterized by open sandy gravel with or without scarce *Zygophyllum simplex* vegetation and was near five-star hotel properties with a service road adjacent to the nesting sites.

Data Collection

Saunders's Terns start migrating into the island during March and depart for the winter in September. The study was conducted from April to June of each year (2017 and 2018), thought the breeding pairs were present before and after the study period. However, it was feasible to continue data collection. The breeding pairs were counted and monitored using binoculars (Steiner Skyhawk 10x42) and spotting scopes (Yukon 6-100x100; SKU2103IK) during the preliminary field surveys to observe the selection of nesting sites. The nests were located, and their GPS locations were recorded (AlRashidi & Shobrak 2015).

One camera trap (ReconyxPC800 Hyperfire Professional IR) was installed approximately 1.5 meters from each nest, and was camouflaged to avoid distress to the birds (AlRashidi & Shobrak 2015). During the camera installation, the egg morphometrics were recorded carefully with a Vernier calliper without disturbing the nest. The cameras were programmed to take five photographs at an interval of one second after every detected movement. Date, time, ambient temperatures were recorded with each photograph. The night vision capacity of the cameras enabled monitoring of the incubation activities even during the night. Incubation bout durations were determined using photographs to determine initiation and cessation times of each bout by a parent. The clutch size and number of hatchlings were recorded. After hatching, the duration of parental care of the chicks was recorded in minutes from the beginning to end through photographs. The activities recorded under parental care included feeding the chicks, brooding, chicks resting in the nest and latent learning. Such behaviors were recorded for a maximum duration of 96 hours after the last hatchling. The chicks could not be further monitored after this period due to their high mobility and frequent movement outside of the camera range. The mean time spent in each activity were then calculated for day and night. The photographs from the camera traps assisted in the detection of the total days of incubation and the egg hatching success or the failure of the nest. The fledging period was considered from the hatching of the egg until the chicks were able to fly in the colony. The disturbance frequency was calculated by counting the number of times the birds were disturbed out of the nests due to the movement of vehicles through the photographs.

Data Analysis

The density of nesting pairs at the breeding site was calculated by dividing the number of nesting pairs by the area of the breeding site. The correlation between the distances of the nests from sea and service road, and hatching success was analyzed using Minitab® 18.1 (Minitab Inc., Pennsylvania, United States). Hatching success was calculated as the percentage of eggs that successfully hatched, nest success was calculated as percentage of hatchlings that successfully left the nest, and fledging success as the percentage of hatchlings that successfully fledged.

The diurnality index of the parental care activities, such as feeding, the time spent by the chicks under the wings of the parents, and exploration and resting by the chick in the presence and the absence of parents were calculated by following formula (Hoogenboom et al. 1984):

$$\text{Diurnality index} = (cd / td - cn / tn) / (cd / td + cn / tn)$$

where cd = sum of the activity values during the day; cn = sum of the activity values during the night; td = numbers of sample intervals during the day; and tn = numbers of sample intervals during the night. The resulting value of the diurnality index is from -1 to +1; negative values suggest nocturnal activity, positive values suggest diurnal activity and a value of 0 suggests similar proportions of nocturnal and diurnal activities (Hoogenboom et al. 1984).

RESULTS

In the present study, 51,942 photographs were analyzed. The percentage of the nests studied from the total nests in the colony was 71%. The density of breeding pairs at the breeding site was 0.94 pairs per hectare in 2017 and 0.68 pairs per hectare in 2018. Nest initiation and first egg-laying occurred in the first week of April. The eggs were pale colored with dark brownish spots for camouflage. The size of the nesting site, total number of nests in the breeding colony, number of nests studied, the distances of nests from the sea, service road, and the nearest neighboring nests, clutch size, egg measurements, incubation period, hatching success, chick nest leaving success, fledging period, and colony fledging success are presented in Table 4. There was a statistically significant difference in the incubation routine between day and night ($Z = 3.05$, $P = 0.0022$). There was non-significant correlation between the hatching success and distances from sea ($r = -0.540$, $p = 0.070$), service road ($r = 0.132$, $p = 0.682$), and neighboring nests ($r = -0.160$, $p = 0.618$).

The diurnality indices of nest disturbance, feeding, parental care, incubation, flying over nest, feeding by chicks, chicks under parents' wings, and exploration of surroundings and resting with and without parents are provided in Table 5. Moreover, the mean (± SE), minimum, and maximum temperatures during various activities of these birds are presented in Table 6.

Table 4. Breeding performance of Saunders's Terns at Sir Bani Yas Island, UAE, in 2017 and 2018. Means are shown ± 1 SE. Differences between neighboring nests were significantly larger in 2018 than in 2017 (Mann-Whitney test, $P < 0.05$); no other differences between 2017 and 2018 were statistically significant.

Parameter	**2017**	**2018**
Nesting area (ha)	11.7	11.7
Number of nests	9[1]	8
Nests studied	6	6
Distance from sea (m)	56 ± 10	76 ± 15
Distance from service road (m)	28 ± 8	40 ± 12
Distance from nearest neighboring nest (m)	28 ± 5	60 ± 6
Clutch size (eggs)	1.33 ± 0.21	1.50 ± 0.22
Egg length (mm)	32.1 ± 0.16	32.1 ± 0.08
Egg breadth (mm)	23.9 ± 0.08	24.0 ± 0.05
Incubation period (A-egg) (d)	19.2 ± 0.45	18.8 ± 0.51
Hatching success (%)	62.5	45
Nest success (%)	80	100
Fledging period (d)	25.6 ± 3.7	27.2 ± 1.4
Colony fledging success (%)	75	86

[1] Excluding two nests deserted soon after nest construction

Out of twelve nests, three nests failed and did not yield any fledglings. The data from the camera traps revealed that out of the failed nests, one nest failed due to predation by feral cats, while two nests failed due to other anthropological factors, such as the movement of vehicles and vehicle noise. The frequency of disturbance at the nests that failed due to anthropological factors revealed that the mean disturbance of the failed nests was substantially higher (52±2 times per day) in comparison to the successful nests (5.6±0.2 times per day).

DISCUSSION

Saunders's Tern preferred coastal areas with scarce vegetation as its preferred breeding sites. Similarly, the closely related species of terns, such as the Little Tern (*Sternula albifrons*) and the Least Tern (*Sternula minutus*) prefer sandy beaches and inland areas up to two kilometers as their breeding sites (Thompson et al. 1997; Oro et al. 2004). According to a study on the biology of Little Tern, 63 % of the nesting colonies were on beaches (Oro et al. 2004). The nest of Saunders's Tern is a depression in the ground, similar to the Little Tern and Least Tern (Thompson et al. 1997; Oro *et al.* 2004).

In the current study, Saunders's Tern were found in loose colonies similar to Little Tern and Least Tern that form colonies up to 30 pairs (Massey 1977; Oro et al. 2004). It may be an adaptation to decrease the intraspecific competition. Living in form of colonies is also an adaptation to avoid predators, thus increasing the survival rate and breeding success of the species. However, not all the birds in the colonies breed (Fraser 2017). In the current study, the pairs involved in breeding were almost half of the colony. The distance between the nests was less in 2017 as compared to 2018. It may be attributed to higher number of breeding pairs.

Table 5. Diurnality Index of different activities of Saunders's Terns at Sir Bani Yas Island, UAE, between 2017 and 2018.

Behaviour	Diurnality Index	2017	2018
Disturbance	0.41	0.42	0.39
Feeding by parents	0.79	0.87	0.75
Parental care	0.91	0.91	0.91
Incubation	-0.12	-0.08	-0.17
Flying over nest	0.42	0.34	0.3
Feeding by chicks	0.82	0.87	0.75
Chicks under parent's wings	0.88	0.87	0.89
Exploration with parents	0.93	0.92	0.94
Exploration without parents	0.68	0.70	0.65
Resting in presence of parents	0.93	-0.44	0.94
Resting in absence of parents	-0.52	-0.53	-0.50

Table 6. Ambient temperatures in relation to different activities of Saunders's Terns at Sir Bani Yas Island, UAE, between 2017 and 2018.

Behaviour	**Temperature (°C)**		
	Average	**Minimum**	**Maximum**
Incubation	33.7 ± 0.6	29.8	38.9
Feeding (Parents)	35.9 ± 0.9	30.1	38.9
Parental Care	35.8 ± 0.7	30.1	38.9
Flying over Nest	35.7 ± 1.3	29.8	38.9
Feeding by Chicks	37.5 ± 0.9	33.8	39.9
Chicks under Parent's wings	36.7 ± 0.7	33.4	39.9
Exploration with Parents	30.8 ± 0.6	29.8	34.5
Exploration without Parents	33.8 ± 0.7	30.1	35.6
Resting in presence of Parents	33.8 ± 0.8	30.1	35.6
Resting in absence of Parents	31.7 ± 0.7	28.8	36.9

The mean clutch size in the current study for Saunders's Tern was lower as compared to the mean clutch size of 2-3 eggs in Least Tern and Little Tern (Thompson et al. 1997; Fraser 2017; Pakanen et al. 2014). There is no previously reported egg measurements for Saunders's Tern to compare the results from the current study. The egg size may indicate the health of breeding pair, quality of habitat and abundance of food and may also affect the hatching success (Oro et al. 2004). In Little Tern and Least Tern, second and third attempts to breed (replacement nests) in the same breeding season have been reported, after failure of earlier breeding attempts. However, the clutch size usually reduced to 1-2 eggs (Fraser 2017). Pakanen (2014) reported 54 % replacement nests in Little Tern. It may be hypothesized that replacement nests can be an attempt to increase breeding success of the colony. However, no hatchling was recorded by Pakanen (2014) out of those replacement nests.

Both parents were observed to take in incubation of the eggs, similar to Little Tern and Least Tern (Thompson et al. 1997; AlRashidi & Shobrak 2005). In the current study, the duration of incubation period was similar to the reported incubation period range of 17-22 days in Little Tern (Fraser 2017).

During the incubation phase, the parents take on the costs of the survival of their eggs and maintain an optimal temperature for the growing chicks in the eggs. These costs may include loss of foraging time and risk of exposure to predators. Moreover, they must combat the harsh weather conditions to protect the growing embryos in the eggs. The optimal temperature for many bird species during incubation is between 36 – 40.5 °C. The timing of breeding season is thus a critical factor to the breeding success and is an adaptation to avoid extreme climatic conditions of the year (AlRashidi &

Shobrak 2015). The recorded temperatures during the breeding season on the island was between 28.8 – 39.9 °C. However, the temperature may rise near to 50 °C later during the year.

AlRashidi and Shobrak (2015) reported that Saunders's Tern incubated more when the ambient temperatures were near or below 25 °C (as temperature below 25 °C can be lethal for the embryo) and incubated less when the temperatures were high. Moreover, they observed less incubation during morning and evening which could be possibly either due to peak foraging times of the parents or predators. Saunders's Tern are pugnacious and defend their nest from predators. Similar behaviour is also reported for Least Tern (Thompson et al. 1997). Parents were observed flying over the nest in the current study, and by AlRashidi and Shobrak (2005). It may be an aggressive behavior to deter the predators. The diurnality index in the current study suggests that the Saunders's Tern incubated more during night as compared to the day times. It may be an adaptation to cope with the lower temperatures during night.

If the birds anticipate high predation risk or the extreme day temperatures are intolerable they may abandon their eggs during incubation (Amat & Masero 2004; Gomez-Serrano & Lopez-Lopez 2014). Similar behavior is reported in Little Tern that abandon their eggs if there is disturbance and heavy rain (Pakanen 2014). Predation is one of the major threats to the breeding success of terns. In the current study, nest predation by cats was one of the contributing factors to the failure of the nest. Similarly, predators like gulls, dogs, and ravens have been reported to affect the breeding success of Little Tern and Least Tern (Swickard 1972; Thompson et al. 1997). Pakanen (2014) reported 60 % of nest failure in Little Tern was due to predation. The chicks moved around in the breeding site, usually staying close to rocks or plants for cover. The same behaviour is reported in the chicks of some other tern species, which demonstrate escape behaviour in response to any threat, covering dozens of meters and seeking immediate cover (Becker & Ludwigs 2004). Chick mortality is reported due to abandonment by the parents, starvation, and exposure to extreme weather conditions in Least Tern (Swickard 1972).

The mean fledgling survival rate was higher in the current study as compared to the mean fledging rate of 45 % in Little Tern (Fraser 2017). Swickard (1972) reported 56-74 % mortality rate from hatchling to fledgling. The deployment of a higher number of camera traps around the breeding site could provide more insight into the movement of feral cats, other wildlife and humans. Therefore, we recommend further studies to extensively cover these limitations and to provide deeper insight into the breeding success of this species.

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Chapter 6

DETERMINING POPULATION TREND AND BREEDING BIOLOGY OF COMMON KESTREL (*FALCO TINNUNCULUS*) AT SIR BANI YAS ISLAND OF EMIRATES

Adopted from: Kabeer B, Bilal S, Abid S, Hejcmanová P, Asadi MA, Jilani MJ and Mehmood A. 2021. Determining population trend and breeding biology of Common Kestrel (*Falco tinnunculus*) at Sir Bani Yas Island of Emirates. Journal of Animal and Plant Sciences. 31 (2): 522-528.

(Please refer to Appendix-IV for accepted article)

INTRODUCTION

Aves are one of the principal classes of vertebrates, surrogated as ecological health indicators. They assist in the assessment of changes in the ecosystem, ecological health, and effects and risks to the ecological set up by climate change and anthropogenic activities (O'Connell et al. 2007). Birds of prey can endorse increased biodiversity by both facilitation of resources and making them available to species that could not otherwise avail them, and by trophic cascades, i.e. by affecting the trophic levels (Sergio et al. 2008). Top predators are used as conservation tools and are very effective to determine ecological health (Ronka et al. 2011). Successful breeding is regarded as an indicator of a healthy and intact ecosystem; any changes in breeding success can immediately provide cues for degrading ecological health that can be a result of environmental changes or anthropogenic catastrophes (Ronka et al. 2011). However, to analyse these effects and aim the interpretations towards the conservation and management interventions, the knowledge of the natural behaviours and variations in the breeding biology of the birds is essential (Ronka et al. 2011).

The reproductive success is influenced by many factors such as photoperiod, availability of food during the breeding season, climate conditions, geographic variation of the breeding areas, presence or absence of predators, as well as the extent of human disturbance. All these factors may affect the onset of the courtship, egg laying, clutch size and fledging success in a given ecological set up (Bustamante & Rodriguez 2003; Carrillo & Gonzalez-Davila 2010; Vasko et al. 2011). Common kestrel (*Falco tinnunculus*) belongs to family Falconidae and is listed as Least Concern (LC) in Red List of Threatened Species by IUCN (BirdLife-International 2016). In the United Arab Emirates (UAE) it is winter visitor and passage migrant with some resident populations (Aspinall et al. 2011). Common kestrel prefers mountainous and rocky areas but is also found in deserts, forests, farmlands, towns and gardens (Aspinall et al. 2011; Anushiravani & Roshan 2017a).

The breeding pairs usually select cliff, tree cavities, crags, poles, artificial nesting boxes or sometimes building structures; they are also known to usurp nests from other species (Hustler, 1983; Anushiravani & Roshan 2017a). The reported start of the courtship and nest selection is late March, and egg laying starts between late April and early May with an average clutch size of 3-6 eggs (Massemin et al. 2002; Valkama et al. 2002). The incubation in common kestrel is reported to be between 27-31 days; and the average fledging period is 27-39 days (Valkama et al. 2002; Anushiravani & Roshan 2017a).

Sir Bani Yas Island was developed as a wildlife reserve for the conservation of endangered species. The island was transformed from barren, arid land to suitable habitat for more than 160 migratory and resident bird species by the plantation of more than two million trees (Mehmood et al. 2014). The abundance of prey species started attracting many raptors including eagles, falcons, harriers, osprey and kestrel. As discussed earlier, to assess the ecological health by surrogating birds of prey, it is imperative to note their behaviours, population trends and breeding pattern over the period to be able to infer the signals of a requirement of conservation intervention. There is no reported study on the breeding of common kestrel in UAE and in Sir Bani Yas Island. The current study was designed to evaluate the population trends and breeding success of common kestrel in Sir Bani Yas Island and to provide an insight to the survival of this species in a restored habitat and to serve as a guideline for further studies and management interventions regarding the conservation of these apex predators.

MATERIALS AND METHODS

Study Area

Sir Bani Yas Island is regarded as the largest natural island in the Emirate of Abu Dhabi, UAE (Figure 8). It is 180 km south-west of Abu Dhabi city and 8 km offshore with a total area of 87km^2 (Kabeer et al. 2020).The island is declared as a protected area for conservation of endangered and indeginous fauna and flora (Mehmood et al. 2014). The detailed description of the study area is presented in Table 7.

Figure 8. Map of Sir Bani Yas Island, UAE, for breeding success study of Common kestrel (*Falco tinnunculus*)

Table 7. Description of the area (Sir Bani Yas Island, UAE) for breeding success study of Common kestrel (*Falco tinnunculus*) (Mehmood et al. 2014).

S.	Parameters	Description
1	Total Area	*8,700 ha*
2	Area of Arabian Wildlife Park (AWP)	*4,100 ha*
3	Coordinates	*24°20' N; 52°36' E*
4	Avg. temp	*18.1-35.8 ^{o} C*
5	Annual rainfall/year	*54.97 – 119.04 mm*
6	Avg. humidity	*26.3% - 56.6%*
7	Total number of animals	*16,000*
8	Total trees planted	*> 2 million*
9	Total number of birds' species	*165*

Data Collection

Population and breeding success of common kestrel was studied from January 2014 till December 2018. Population of common kestrel was monitored through line transect method monthly (Sutherland et al. 2004). The island was categorised into three habitat types viz. Mountains, Forests, and Pastures/open land. In each habitat category, two transects were laid; each transect was 2,000 meters long and 200 meters wide on each side (L = 2,000 m; W = 400 m) (Anwar et al. 2015). Each transect was visited once a month. Two transects were at least 1,000 meters apart from each other. A pair of binoculars (Steiner Skyhawk 10x42) and a camera (Nikon

DSLR 3200 with 400 mm lens) was used to identify and record the birds (Anwar et al. 2015). The species identification was verified through field guide “Birds of the United Arab Emirates - A guide to common and important species (Aspinall et al. 2011).

The birds were observed to identify their nesting sites. Once located, the nests were identified and their locations were recorded (AlRashidi & Shobrak, 2015). To monitor breeding activities, each nest was monitored early morning (7 to 8 am), afternoon (12-1 pm) and late evening (4:30 to 5:30 pm) for one hour each (three hours per day). The observation time and activities were limited to avoid disturbance and undue stress to the nesting birds. Moreover, it was not feasible to observe birds throughout the day. The monitoring of nests throughout the day was not feasible due to logistical constraints. The team was properly camouflaged while monitoring the nests with binoculars. Each monitoring was done by a team of two observers. During 2017 and 2018, multiple teams were used to collect breeding data due to additional nests. The incubation and fledging periods were recorded. Moreover, clutch size, number of hatchlings, and number of fledglings were also recorded for each nest. Other parameters such as the times where parents were feeding the chicks, and chicks with and without parents were also recorded (Antonov et al. 2007; Poirazidis et al. 2009).

Statistical Analysis

The population and habitat selection parameters were subjected to Kruskal-Wallis H Test using Minitab® 18 statistical software. Hatching success percentage was calculated by dividing number of hatchlings with the clutch size; the fledging success percentage was calculated by dividing number of fledglings with the number of hatchlings. Additionally, the survival rate percentage was calculated by dividing the number of successful fledglings with the clutch size (Antonov et al. 2007).

RESULTS

The population (mean ± SE) was 8.17 ± 0.60, 9.75 ± 0.55, 10.50 ± 0.56, 12.42 ± 0.84, and 16.67 ± 1.50 individuals during 2014, 2015, 2016, 2017, and 2018 respectively. Kruskal-Wallis Test confirmed a statistically significant difference (H-Value = 22.07, DF = 4, *P*-Value = 0.00019) in the populations over the course of five years i.e. from 2014 – 2018 (Figure 9). The higher population density was from April to September (Figure 10).

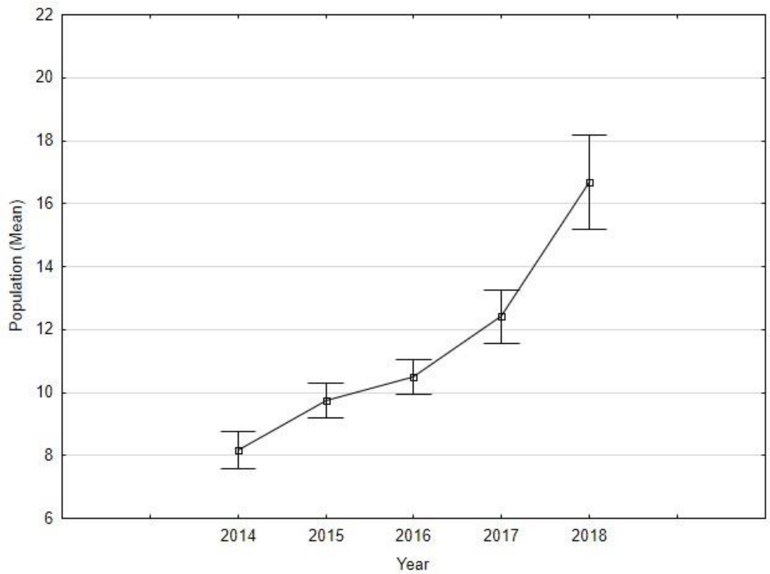

Figure 9. Yearly population trend of Common kestrel (*Falco tinnunculus*) from 2014-2018 at Sir Bani Yas Island, United Arab Emirates

The population data from three habitat types showed statistically significant difference (Kruskal-Wallis Test) in preference of habitat types (H-Value = 27.43, DF = 2, *P*-Value = 0.0000011) (Figure 9). The mean population during each year in different habitat categories is presented in Table 8. The birds showed clear preference of open/pasture habitats, especially for feeding. They used to select a vantage point such as a tree top or a pole and search for prey from it. In breeding season, they chose mountains.

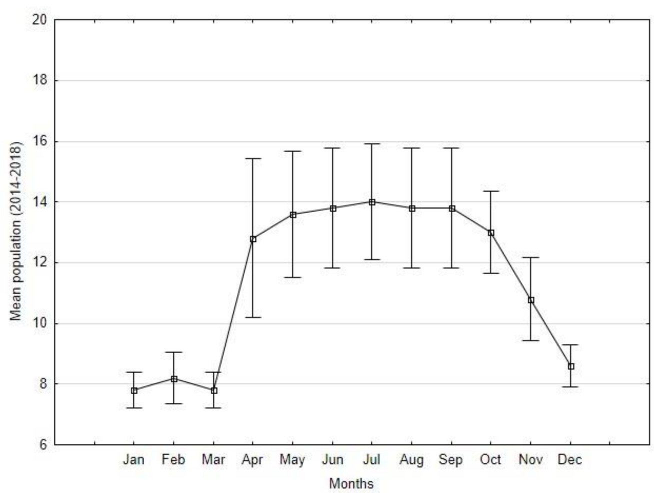

Figure 10. Monthly population trend of Common kestrel (*Falco tinnunculus*) from 2014-2018 at Sir Bani Yas Island, United Arab Emirates

During the study period total eight nests were monitored. Common kestrel on Sir Bani Yas Island preferred small crevices or cavities on vertical cliffs of the mountains (87.5 %) about 12-15 feet above ground or on the top of high tower (12.5 %) more than 100 meters high. The average height of the nest was 31.81 cm with an average width of 25.70 cm. The birds also preferred same nesting sites used during previous breeding season. Common kestrel started courtship and nesting during early April and the egg laying started during late April. The average clutch size was 3.75 ± 0.31 eggs with a range of 2-5 eggs per clutch. The average incubation period was 29.13 ± 0.52 days (range = 27-31 days); resulting in average hatchlings of 3.50 ± 0.53 chicks. The hatching and fledging success are given in Table 9. All the hatchlings successfully fledged the nest. Only one nest failed and yielded no hatchlings. The mean fledging period was 35.63 ± 5.16 days (range = 37 – 45 days).

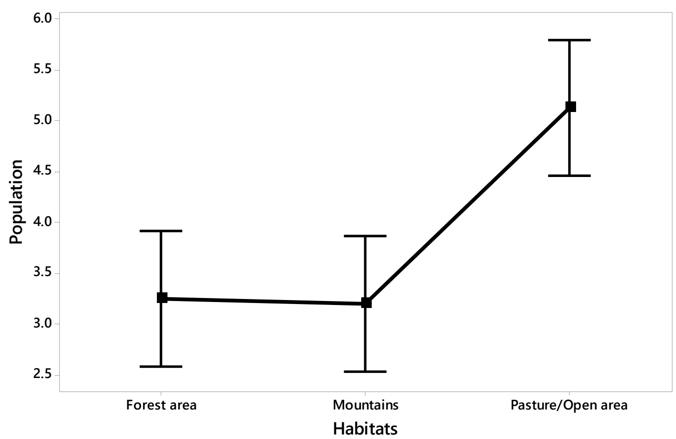

Figure 11. Population trend of Common kestrel (*Falco tinnunculus*) in different habitat types from 2014-2018 at Sir Bani Yas Island, United Arab Emirates

The eggs were incubated 74.02 ± 1.69 percent of the total incubation period. The incubation was mostly by female, where male would incubate during her absence only and for shorter durations. While they were unattended 24.54 ± 1.64 percent of the total incubation duration (Table 10). Parents spent 1.44 percent time feeding in the nests, where male would bring food for the female. During the total fledging period, 68.22 ± 0.46 percent time the parents attended the chicks; whereas, the chicks were unattended in the nests 28.09 ± 0.43 percent of the time and 3.69 ± 0.16 percent of the fledging period was spent by chicks on feeding (Figure 12). The hunting technique varied during breeding and non-breeding season, as common kestrel used flight-hunting as major hunting technique during breeding season, whereas, they used both flight and perch-hunting techniques during non-breeding season.

Table 8. Mean population of Common kestrel (*Falco tinnunculus*) during the study period at Sir Bani Yas Island, United Arab Emirates.

Year	Population Mean ± SE in Different Habitat Types		
	Mountains	**Forest area**	**Pasture/Open area**
2014	2.17 ± 0.51	2.58 ± 0.31	3.42 ± 0.53
2015	2.25 ± 0.60	3.08 ± 0.23	4.42 ± 0.42
2016	2.50 ± 0.63	3.08 ± 0.31	5.08 ± 0.56
2017	3.17 ± 0.81	3.33 ± 0.48	5.92 ± 0.79
2018	5.92 ± 1.46	4.17 ± 0.82	6.83 ± 1.11

DISCUSSION

The population trend, habitat preference and breeding success of the common kestrel were studied first time on Sir Bani Yas Island. Birds of prey can impact the bird diversity of an area by regulating the resources and controlling the prey populations (Sergio et al. 2008).

The results of current study show a steadily establishing population of common kestrel on Sir Bani Yas Island. The increase in population suggests abundance of resources (such as shelter and prey) on the island and the success of the extensive afforestation efforts to create a suitable habitat for endangered, resident and migratory fauna on the island (O'Connell et al. 2007). Moreover, the island being declared as protected area has also added up further protection to the birds in terms of illegal hunting and trapping. There was a surge in population from late April until September on the island. The population was higher during these months due to addition of hatchlings and later declined when the fledglings dispersed out of the island in October.

Common kestrel preferred habitats with pastures and open areas during non-breeding season and for predation. This could be attributed to the abundance of the prey and clear vantage to search their prey species. During breeding season, the birds preferred nesting in mountainous habitats. This preference can be due to the safety and privacy of the nests and chicks (Roberts 1991). The preferred habitat of common kestrel coincides with our findings; as they are reported to exist in mountainous areas, forests, farmland and pastures (Casagrande et al. 2008; Aspinall et al. 2011; Anushiravani & Roshan 2017a).

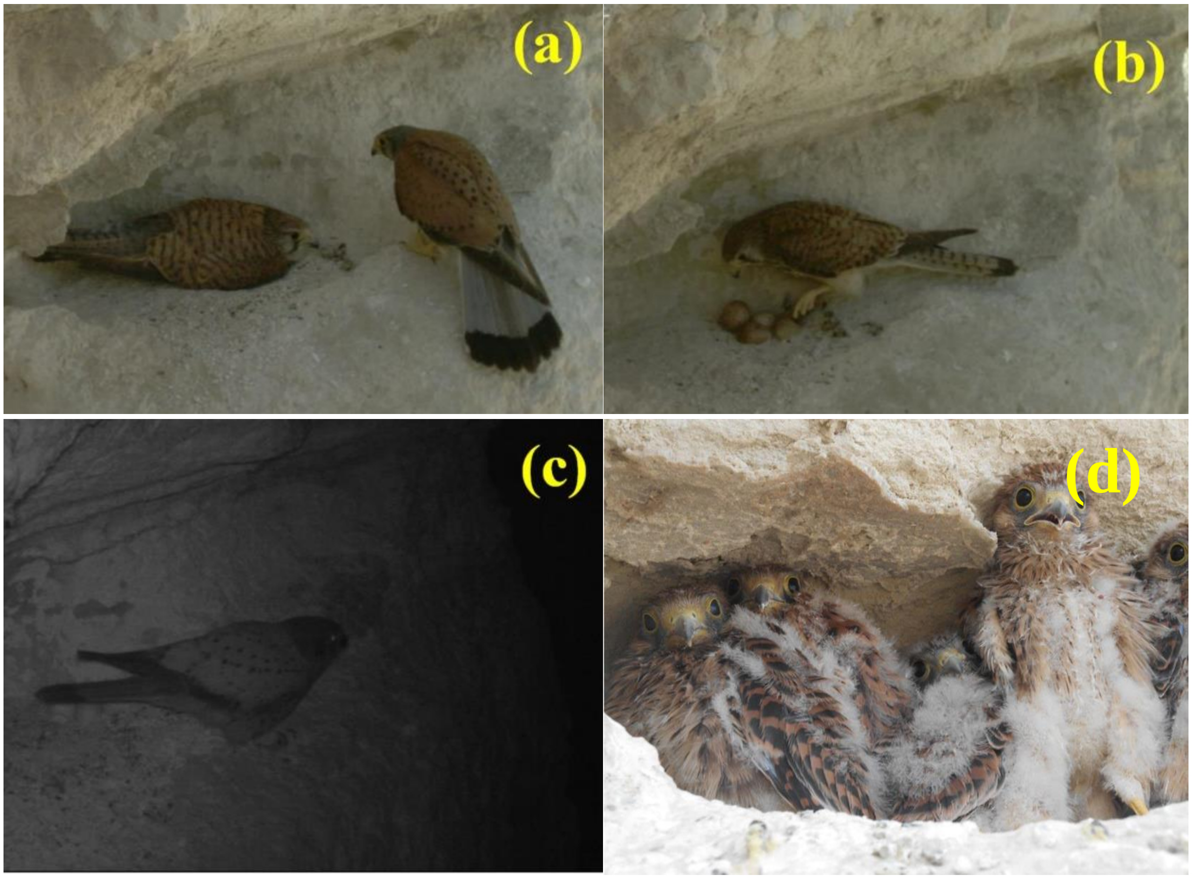

Figure 12. Photographs of Common kestrel (*Falco tinnunculus*) at Sir Bani Yas Island, United Arab Emirates (a) presence of both parents at nest (b) female turning eggs during incubation (c) female during incubation at night (d) chicks in the nest waiting for parents to bring food.

The gradually establishing population and successful breeding of common kestrel on Sir Bani Yas Island also indicates the good health of the ecosystem as successful breeding is directly proportional to the ecological health (Ronka et al. 2011). The preference of nesting site was for small crevices and cavities in the mountainous areas. Other studies also suggest that common kestrels prefer cliffs as nesting sites but are also found to nest on artificial structures and even nest boxes (Shrubb 1993). The average nest dimensions of common kestrel nests were higher than the dimensions in studies from (Anushiravani & Roshan 2017) who reported the nest dimensions from 32 sites to be 19.7 x 21.9 cm. However, this could be dependent on the availability of the good nesting sites, as the pair was not observed to expand the nests or to alter them significantly from their original condition.

The average clutch size in the current study was within the described range of 3-6 eggs (Massemin et al. 2002; Valkama et al. 2002); but the mean clutch size was lower as compared to 5.03 ± 0.7 eggs in a study conducted in Iran (Anushiravani & Roshan 2017a). Only one nest had a lower clutch size of two eggs and was the only nest that failed to produce any hatchlings. Due to failure of one nest the hatching success dropped to 87.50 ± 12.50 percent; as all other nests had 100% hatching rate. Due to abundant food supply and critical nesting site selection, the fledging success was cent per cent. The hatching rate (87.50 %) was higher in our study compared to 84.4% reported in Iran along with the fledging rate which was previously reported as 73.9% (Anushiravani & Roshan. 2017a).

Table 9. Breeding success of Common kestrel (*Falco tinnunculus*) during the study period at Sir Bani Yas Island, United Arab Emirates.

Breeding Success Variables	**Value**
Number of Nests	**8**
Average Clutch size (Numbers)	**3.75 ± 0.31**
Average number of hatchlings	**3.50 ± 0.53**
Average number of fledglings	**3.50 ± 0.53**
Hatching Success (Percentage)	**87.50 ± 12.50**
Fledging success (Percentage)	**100.0 ± 0.00**
Total Nests Failed (Numbers)	**1**

Table 10. Incubation and Parenting routine of Common kestrel (*Falco tinnunculus*) during the study period at Sir Bani Yas Island, United Arab Emirates.

Incubation and Parenting Variables	**Value (Mean ± SE)**
Total incubation period	**29.13 ± 0.52 Days**
Time for eggs incubation by parents during incubation period	**74.02 ± 1.69 %**
Feeding time by parents during incubation	**1.44 ± 0.13 %**
Time during incubation while eggs were unattended	**24.54 ± 1.64 %**
Total fledging period	**35.63 ± 5.16 Days**
Time Chicks were attended by parents during fledging period	**59.70 ± 8.54 %**
Time Chicks were unattended by parents during fledging period	**24.57 ± 3.53 %**
Time chicks were fed during fledging period	**3.23 ± 0.48 %**

The incubation period in the current study coincided with the previous studies ranging from 27 – 31 days; the average fledging period in the current study was similar to the previous studies on common kestrel (Valkama et al. 2002; Charter et al. 2008; Anushiravani & Roshan 2017a).

The eggs were incubated 75% of the total incubation period and were left unattended 25% of the time during incubation period. Due to the choice of nesting site, there was no threat to the unattended eggs or chicks (unattended in the nest about 28% of total fledging period). All the nests were inaccessible to humans, predators or other animals. However, in the failed nest there were pugmarks of rock hyrax (*Procavia capensis*) near the nest. We could not establish a link of rock hyrax presence to the failure of the nest; due to absence of concrete evidence.

The male brought food for female 1.44% of the incubation time when female did not leave the nest for feeding; the male would bring food to the female. Mostly the prey species brought by the male were ocellated skink (*Chalcides ocellatus*), gecko species, gerbil species, parts of rock pigeon (*Columba livia*) and grey francolin (*Francolinus pondicerianus*). There were also many other prey items that could not be identified with binocular. Various studies have reported 49 prey items (Charter et al. 2008) 172 prey items (Anushiravani & Roshan 2017b) and 349 prey items (Gao et al. 2009) for common kestrel during breeding season. Considering the abundance of prey species, safe nesting sites and successful breeding; it is indicative that the ecological health at Sir Bani Yas Island is in favour of biodiversity, especially propagation of raptors.

Successful breeding and healthy population is regarded as an indicator of a healthy and intact ecosystem; any decline in breeding success and population can immediately provide cues for degrading ecological health that can be a result of environmental changes or anthropogenic catastrophes. This could be attributed to the presence of the prey and clear vantage to search their prey species. Common kestrel started courtship and nesting during early April and the egg laying started during late April. Both parents take part in incubation and rearing of chicks. Male was more involved in hunting and feeding operations for the female and chicks.

Conclusion

The increase in population of Eurasian Kestrel during the study period suggests abundance of resources on the island and the success of the extensive afforestation efforts to create a suitable habitat. The bird prefers pastures and open areas during non-breeding season and for predation. The finding of this study could be used as future reference to study the breeding success of the species and provide cues for further improvement of the ecosystem conditions by improving the habitat condition at the Island. However, the observations on incubation and parental care can be further studied using camera traps to have concrete information on nest failure.

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Chapter 7

BREEDING OF THE OSPREY (*PANDION HALIAETUS*) IN NATURAL AND ARTIFICIAL NESTING SUBSTRATES IN THE UNITED ARAB EMIRATES (AVES: ACCIPITRIFORMES)

Adopted from: Kabeer B, Bilal S, Abid S, Hejcmanová P, Asadi MA, Jilani MJ and Mehmood A. Breeding of the Osprey, (*Pandion haliaetus*) in natural and artificial nesting substrates in the United Arab Emirates (Aves: Accipitriformes). Zoology in the Middle East. 2020 Apr 2; 66(2):186-8.

(Please refer to Appendix-V for accepted article)

INTRODUCTION

The osprey (*Pandion haliaetus*) has a cosmopolitan distribution and it is a not rare breeder in some coastal areas in the United Arab Emirates, Bahrain, and Oman in the Arabian Gulf region (Jennings 2010; Khan et al. 2008). The species is predominantly a ground nester in Arabia, but it also takes advantage of human-made constructions such as abandoned buildings or electricity pylons (Jennings 2010). Artificial nesting platforms have been installed in the United Arab Emirates to aid reproduction and to overcome a lack of a sufficient number of suitable nesting sites. Nest platforms are known to have a positive effect on the breeding productivity of ospreys and other raptors (Brown & Collopy 2008; Hunt et al. 2013). There was no osprey breeding activity reported on the island before 2014. The current study therefore compares the breeding success of a small population of ospreys on the mainland and on the neighbouring island and evaluates the efficency of artificial nesting platforms which have been established to enhance breeding success.

METHODS

The study was conducted at two locations in the western region of Abu Dhabi, United Arab Emirates. The first location was Sir Bani Yas Island that has a total area of 87 km² and was developed and defined as a protected wildlife reserve. Initially, the island consisted of barren arid land, and according to the master plan for its development, more than two million trees were planted to provide a suitable habitat for endangered fauna, especially for bird species on the island (Dhaheri et al. 2017a). The second study site was 4600 ha forest, located 350 km from Abu Dhabi and is one of the protected areas near Al Sila city.

Every year from 2014 to 2019, both study areas were surveyed to locate nests. All active nests were marked using a handheld GPS unit (Garmin, etrex) and information such as nest height, diameter, material used in nest construction, altitude from sea level, distance from nearest human establishment, paved and unpaved roads was recorded using measuring tape (Ali et al. 2015). Nest type was assigned either as natural nests if the nests were on any naturally occurring structure (i.e. rock, ground or tree) or artificial nesting platform if the nest was on a human-made platform (Khan et al. 2008).

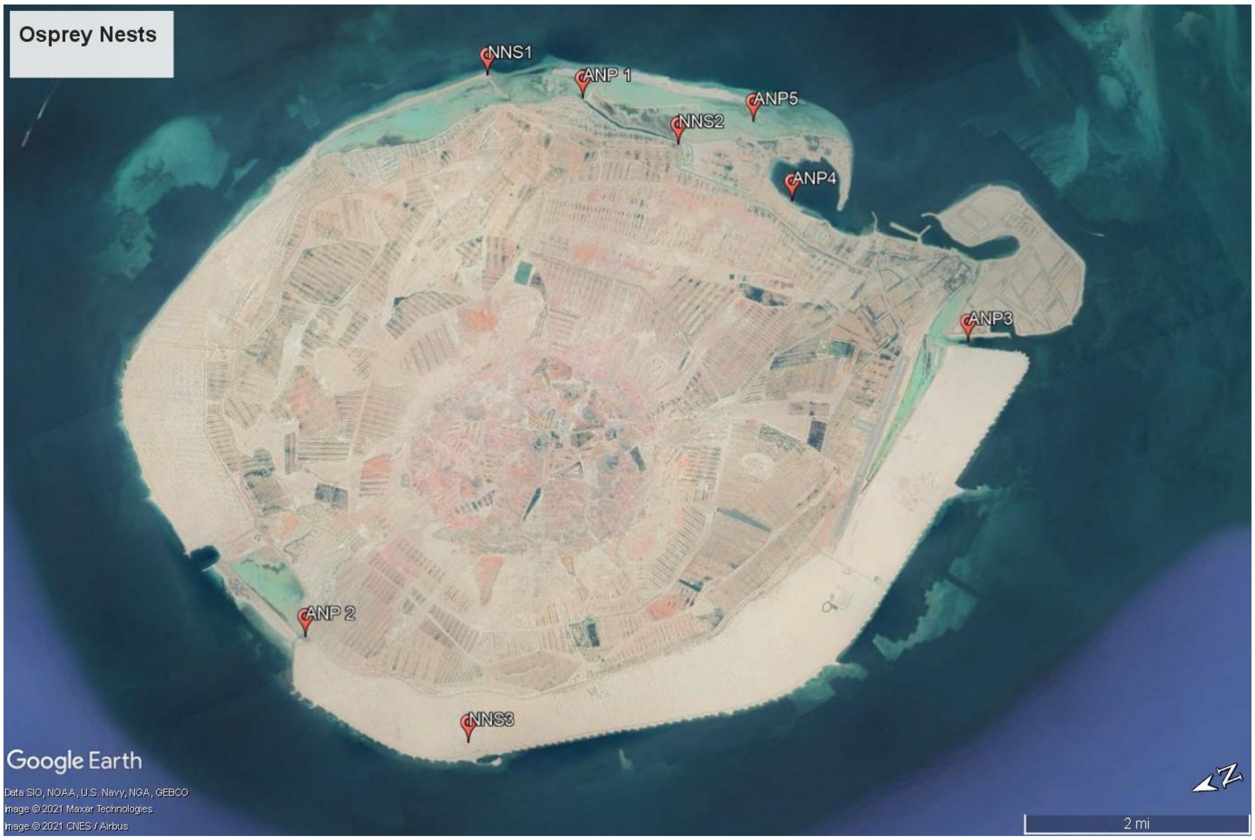

Figure 13: Osprey nest locations on Sir Bani Yas Island, including natural nesting sites (NNS) and artificial nesting platforms (ANP)

RESULTS AND DISCUSSION

A total of nine natural nests were observed in Al Sila, and three natural and five nests on platforms in Sir Bani Yas Island (Table 11). These platforms were constructed at the end of 2016 to provide more nesting sites to the birds on the island after unsuccessful breeding on natural nesting sites.

Table 11. Nest types, hatching and breeding success of Osprey (*Pandion haliaetus*) on mainland and Sir Bani Yas Island in the United Arab Emirates.

Location	Nest Type	Nest ID	Year	No of Eggs	No of hatchlings	No of fledgelings	Hatching Success	Fledging success
Al Sila	Natural: mainland	ASN-1	2014	3	3	3	100.0	100.0
		ASN-2	2015	2	2	2	100.0	100.0
		ASN-3	2015	3	2	2	66.7	100.0
		ASN-4	2016	3	3	2	100.0	66.7
		ASN-5	2017	3	2	2	66.7	100.0
		ASN-6	2017	2	2	1	100.0	50.0
		ASN-7	2018	3	3	2	100.0	66.7
		ASN-8	2018	3	1	1	33.3	100.0
		ASN-9	2019	3	3	3	100.0	100.0
SBY	Natural: island	NNS-1	2014	3	2	0	66.7	0.0
		NNS-2	2015	0	0	0	0.0	0.0
		NNS-3	2016	0	0	0	0.0	0.0
	Platform: island	ANP-1	2017	3	2	2	66.7	100.0
		ANP-2	2018	2	2	1	100.0	50.0
		ANP-3	2018	3	2	2	66.7	100.0
		ANP-4	2019	3	3	2	100.0	66.7
		ANP-5	2019	2	2	2	100.0	100.0

The stages of breeding such as incubation, hatching, and fledging success was recorded. The activity was observed through binoculars or a spotting scope. The observations were taken from a vantage point ranging from 50 to 150 metres depending upon the site characteristics and the response of the birds to the observer (Clancy 2006). Information such as disturbance due to developmental activities and interspecies competition were also recorded. The nests were monitored daily, early morning and late evening for 30 minutes.

The hatching success was calculated by taking the percentage of hatchlings out of clutch size, and the fledging success was calculated by taking the percentage of fledgelings out of the total number of hatchlings. The data were analysed using the non parametric Man-Whitney U Test in Statistica 10 statistical software for data between locations, nest types, and years.

Nest construction starts earliest in early December. Out of 17 nests studied, the birds used the same nest 14 times. The same nests were used nine times at the two locations in Al Sila forest, and five times at the two platforms at Sir Bani Yas Island.

In 2014, only one breeding pair of Ospreys was recorded on Sir Bani Yas Island. They constructed a nest on a sand berm at the edge of the beach and laid three eggs. Only two eggs hatched with a hatching success of 66.7%. Both young died on the fourth day due to a robust cold gale, eventually leading to zero fledging success. In 2015 and 2016, the birds constructed nests but did not lay any eggs. In 2015, they constructed a nest on a telecommunication tower but abandoned it without laying eggs. Later, Egyptian Geese (*Alopochen aegyptiaca*) took over the nest.

The average clutch size in the natural nesting sites was 2.33±1.15 eggs per nest, while it was 2.60±0.55 for nests on platforms. The difference is statistically not significant (U=30.0; P=1.0) (Table 1). The mean incubation period was 35.0±2.16 days for all nests. The mean number of hatchlings was 1.92±1.08 in natural nesting sites and 2.20±0.45 hatchlings at nesting platforms. The difference was statistically not significant (U=28.0; P=0.87). The mean hatching success was 69.44±38.82 per cent in natural nests, and 86.67±18.26 per cent at nesting platforms. Neither were these differences was significant (U=24.0; P=0.56).

The mean fledging period of all nests was 53.0±4.58 days. The mean number of fledgelings in natural nests was 1.50±1.09 fledgelings compared to 1.80±0.45 fledgelings in the platform nests on the island (difference not significant; U=26.0; P=0.71). The mean fledging success was 65.28±42.91 per cent for natural nesting sites and 83.33±23.57 per cent for nesting platforms. The platform occupancy rate was 33% in 2017 and 67% in 2018 and 2019.

Multiple factors could have attributed to the failure of egg-laying, such as continuous disturbance from Egyptian Geese and the construction of a new cruise ship beach. Geese are reported to take over Osprey nests and artificial platforms in many areas (Henny et al. 1978). Moreover, in 2016, construction works were the cause of disturbance.

CONCLUSIONS

The present study shows that the provision of nesting platforms was successful in enhancing the reproduction rate of the Ospreys on the island. The nests on platforms were more successful in producing fledgelings compared to nests on natural substrates in disturbed habitats and with interspecies competition for nesting sites. The provision of platforms reduces competition for nesting sites and provides safety to adults and young.

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Chapter 8

SYNTHESIS AND CONCLUSIONS

We may conclude that the intensive habitat management practices in desert regions can support the avian diversity. The ecological modifications (afforestation and irrigation) on the island coupled with protection of natural, unmanaged parts, i.e. mountains and coast, provide a mosaic of habitats and enhance ecosystem heterogeneity with the broader regional impact on Arabian Peninsula. Certain considerations should be paid to synanthropic species which are supported not directly by afforestation, but by additional intensive management of large wildlife species, increase in abundance and demonstrate negative co-occurrence with other species.

There was an obvious and conspicious difference in species diversity and abundance before and after afforestation over a period of four decades. Planted pastures and forests cumulatively accommodated high numbers of species. The coastal area provided a suitable habitat for migratory water birds that migrated in during winters. Some used the island as a stopover location while others bred and migrated out with their fledglings. Afforested areas also served as a source of food to the birds belonging to various feeding guilds.

Majority of the species recorded were migratory, while many migrated to breed on the island and raise their chicks. From the diverse nineteen avian orders recorded on the island most diversity was from the orders Passeriformes and Charadriiformes inhabiting afforested area and coastline, respectively. In the coastal areas the species of gulls and terns had higher abundance as they migrated in during the winter months on the island. While in afforested areas sparrows, doves, bulbuls were abundant. These results suggest the island is an important migratory stopover for many species in the region. The water birds are declining at an alarming state due to fishing and habitat loss. The island provides a haven for water birds species as it is a protected area.

Intensive habitat management not only offers suitable habitat for bird species, but it also offers suitable habitat for various other living organism such as insects, reptiles, and rodents. These invertebrates and smaller fauna are a source of food for the bird species as well along with the fruits, grains and other forest food items that an afforested area provides to the bird species. In the current study, the highest numbers of species were insectivorous and carnivorous according to their feeding guild followed by granivorous and omnivorous. It is also an indirect sign of abundance and diversity of other fauna that provides a rich source of food to the avifauna.

The increase in population of the breeding pair during the study period suggests abundance of resources on the island and the success of the extensive habitat management efforts to create a suitable habitat. The birds of prey, such as kestrel, preferred pastures and open areas during non-breeding season and for predation. This could be attributed to the abundance of the prey and clear vantage to search their prey species. During breeding season, the birds preferred nesting in habitats that were safe from predators such as the kestrel that nested in mountain habitats. This preference can be due to the safety and privacy of the nests and chicks.

The conservation intimation of nesting platforms was very successful in enhancing the success rate of osprey breeding on the island. The nests on platforms were more successful in producing the fledgelings compared to nests on non-assisted substrates in disturbed habitats and with interspecific competition for nesting sites. The provision of the platforms reduced competition for nesting sites and provided safety to the breeding pairs and chicks. The platforms can be placed away from human disturbance and provide a suitable substitute for a natural substrate.

Our results confirmed that Saunders's terns are sensitive to disturbance during incubation and thus leave the nests for prolonged periods if disturbed. Eggs with great disturbance during the incubation period failed to hatch. Feral cats were also recognised as a predator of the eggs and were responsible for nest failure. The diurnality index for the incubation period showed that the birds spent more time with the eggs during the night. Parents mostly flew over the nest during the day for surveillance. The disturbance during the incubation period was higher during the day. Parental care activities such as feeding chicks, time spent by the chicks under the wings of the parents, exploration and resting by the chicks in the presence of parents, and activities of the chicks such as exploration without parents were diurnal activities. The only nocturnal activity shown by the chicks was resting in the absence of parents. The diurnality index of the feeding frequency was also skewed towards the day. The chicks were challenging to monitor with camera traps once hatched, usually due to their constant movements. Given these results, we consider the rate of breeding failure to be rather high and mostly caused by disturbance linked to vehicle movements during the day and predation by feral cats at night. We can, therefore, suggest limiting the active human presence and controlling the feral cats in the nesting area during the breeding period of the year as the most effective conservation measure for Saunders's tern.

The finding of this study provide an insight into the positive impacts of intensive habitat management on the avian diversity and breeding success. The mosaic of natural and intensively managed planted vegetation cover provided suitable set of environmental conditions for the bird communities to thrive on the island.

Chapter 9

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APPENDICES

Appendix I: Avian species recorded on Sir Bani Yas Island during the study period (2014-2018)

S	Scientific name	Abbreviation	Order	Family	English name	Feeding guild	Red List status	Migratory /Resident
1	*Acridotheres tristis*	AcriTri	*Passeriformes*	Sturnidae	Common Myna	O	LC	R
2	*Acrocephalus stentoreus*	AcroSte	*Passeriformes*	Acrocephalidae	Clamorous Reed Warbler	I	LC	M
3	*Actitis hypoleucos*	ActHyp	*Charadriiformes*	Scolopacidae	Common Sandpiper	C	LC	R
4	*Alaemon alaudiopes*	AlaAla	*Passeriformes*	Alaudidae	Greater Hoopoe-Lark	I/G	LC	M
5	*Alauda arvensis*	AlaArv	*Passeriformes*	Alaudidae	Eurassian Skylark	G/I	LC	M
6	*Alcedo atthis*	AlcAtt	*Coraciiformes*	Alcedinidae	Common kingfisher	P	LC	M
7	*Alectoris chukar*	AleChuc	*Galliformes*	Phasianidae	Chukar Partridge	G	LC	R
8	*Alopochen aegyptiaca*	AloAeg	*Accipitriformes*	Anatidae	Egyptian Goose	O	LC	R
9	*Ammomanes deserti*	AmmoDes	*Passeriformes*	Alaudidae	Desert Lark	I/ G	LC	M
10	*Ammoperdix griseogularis*	AmmoGri	*Galliformes*	Phasianidae	See-see Partridge	I	LC	R
11	*Anas platyrhynchos*	AnaPla	*Accipitriformes*	Anatidae	Mallard	O	LC	M
12	*Anser albifrons*	AnsAlb	*Accipitriformes*	Anatidae	Greater White Fronted Goose	O	LC	M
13	*Anthus campestris*	AntCam	*Passeriformes*	Motacillidae	Tawny Pipit	I	LC	M
14	*Anthus cervinus*	AntCer	*Passeriformes*	Motacillidae	Red-throated Pipit	I	LC	M
15	*Anthus richardi*	AntRich	*Passeriformes*	Motacillidae	Richard's Pipit	I/ G	LC	M

16	*Anthus spinoletta*	AntSpi	*Passeriformes*	Motacillidae	Water Pipit	I	LC	M
17	*Anthus trivialis*	AntTri	*Passeriformes*	Motacillidae	Tree Pipit	I	LC	M
18	*Apus pallidus*	ApuPal	*Accipitriformes*	Apodidae	Pallid Swift	I	LC	M
19	*Aquila chrysaetos*	AquChry	*Accipitriformes*	Accipitridae	Golden Eagle	C	LC	M
20	*Aquila fasciata*	AquFas	*Accipitriformes*	Accipitridae	Bonelli's Eagle	C	LC	M
21	*Aquila heliaca*	AquHel	*Accipitriformes*	Accipitridae	Eastern imperial Eagle	C	VU	M
22	*Ardea alba*	ArdAlb	*Pelecaniformes*	Ardeidae	Great Egret	C	LC	M
23	*Ardea cinerea*	ArdCin	*Pelecaniformes*	Ardeidae	Grey Heron	C	LC	R
24	*Ardea purpurea*	ArdPur	*Pelecaniformes*	Ardeidae	Purple Heron	C	LC	M
25	*Arenaria interpres interpres*	AreInt	*Charadriiformes*	Scolopacidae	Ruddy Turnstone	I	LC	M
26	*Balearica regulorum*	BalReg	*Gruiformes*	Gruidae	Grey Crowned Crane	O	EN	R
27	*Bubulcus ibis*	BubIbi	*Pelecaniformes*	Ardeidae	Western Cattle Egret	C	LC	M
28	*Burhinus oedicnemus*	BurOed	*Charadriiformes*	Burhinidae	Eurasian Stone-Curlew	O	LC	M
29	*Butorides striata*	ButStr	*Pelecaniformes*	Ardeidae	Striated Heron	C	LC	M
30	*Calidris alba*	CalAlb	*Charadriiformes*	Scolopacidae	Sanderling	I	LC	M
31	*Calidris alpina*	CalAlp	*Charadriiformes*	Scolopacidae	Dunlin	I	LC	M
32	*Calidris falcinellus*	CalFal	*Charadriiformes*	Scolopacidae	Broad-billed Sandpiper	I	LC	M
33	*Calidris ferruginea*	CalFer	*Charadriiformes*	Scolopacidae	Curlew Sandpiper	I	LC	M
34	*Calidris minuta*	CalMin	*Charadriiformes*	Scolopacidae	Little Stint	C	LC	M
35	*Calidris pugnax*	CalPug	*Charadriiformes*	Scolopacidae	Ruff	I	LC	M
36	*Calidris temminckii*	CalTem	*Charadriiformes*	Scolopacidae	Temminck's Stint	C	LC	M
37	*Caprimulgus europaeus*	CapEur	*Caprimulgiformes*	Caprimulgidae	European Nightjar	I	LC	M

38	*Cercotrichas galactotes*	CerGal	*Passeriformes*	Muscicapidae	Rufous-tailed Scrub Robin	I	LC	M
39	*Cercropis daurica*	CerDau	*Passeriformes*	Hirundinidae	Red-rumped Swallow	I	LC	M
40	*Charadrius alexandrinus*	CharAle	*Charadriiformes*	Charadriidae	Kentish Plover	I	LC	M
41	*Charadrius dubius*	CharDub	*Charadriiformes*	Charadriidae	Little Ringed Plover	I	LC	M
42	*Charadrius hiaticula*	CharHia	*Charadriiformes*	Charadriidae	Common Ringed Plover	O	LC	M
43	*Charadrius leschenaultii*	CharLes	*Charadriiformes*	Charadriidae	Greater Sand Plover	I	LC	M
44	*Charadrius mongolus*	CharMon	*Charadriiformes*	Charadriidae	Lesser Sand Plover	I	LC	M
45	*Chlamydotis undulata*	ChlaUnd	*Otidiformes*	Otidae	Houbara bustard	O	VU	R
46	*Chlidonias hybrida*	ChliHyb	*Charadriiformes*	Laridae	Whiskered Tern	C	LC	M
47	*Chroicocephalus genei*	ChroGen	*Charadriiformes*	Laridae	Slender billed Gull	C	LC	M
48	*Chroicocephalus ridibundus*	ChrRid	*Charadriiformes*	Laridae	Black-headed Gull	C	LC	M
49	*Chroicocephalus saundersi*	ChroSau	*Charadriiformes*	Laridae	Saunder’s Tern	C	LC	M
50	*Cinnyris asiaticus*	CinAsi	*Passeriformes*	Nectariniidae	Purple Sunbird	N	LC	M
51	*Circus aeruginosus*	CirAer	*Accipitriformes*	Accipitridae	Western Marsh Harrier	C	LC	M
52	*Circus macrourus*	CirMac	*Accipitriformes*	Accipitridae	Pallid Harrier	C	NT	M
53	*Circus pygargus*	CirPyg	*Accipitriformes*	Accipitridae	Montagu’s Harrier	C	LC	M
54	*Clanga Clanga*	ClaCla	*Accipitriformes*	Accipitridae	Greater Spotted Eagle	C	VU	M
55	*Columba livia*	ColLiv	*Columbiformes*	Columbidae	Rock Dove	G	LC	R

56	*Coracias benghalensis*	CorBen	*Coraciiformes*	Coraciidae	Indian roller	C	LC	M
57	*Coracias garrulus*	CorGar	*Coraciiformes*	Coraciidae	European Roller	G/I	LC	M
58	*Corvus splendens*	CorSpl	*Passeriformes*	Corvidae	House Crow	S	LC	R
59	*Coturnix coturnix*	CotCot	*Galliformes*	Phasianidae	Common Quail	G	LC	R
60	*Delichon urbicum*	DelUrb	*Passeriformes*	Hirundinidae	Common House Martin	I	LC	M
61	*Egretta garzetta*	EgrGar	*Pelecaniformes*	Ardeidae	Litte Egret	C	LC	M
62	*Egretta gularis*	EgrGul	*Pelecaniformes*	Ardeidae	Western Reef Heron	C	LC	R
63	*Emberiza calandra*	EmbCal	*Passeriformes*	Emberizidae	Corn Bunting	G	LC	M
64	*Emberiza hortulana*	EmbHor	*Passeriformes*		Ortolan Bunting	I	LC	M
65	*Eremopterix nigriceps*	EreNig	*Passeriformes*	Alaudidae	Black-crowned sparrow-lark	I/G	LC	M
66	*Euodice malabarica*	EuoMal	*Passeriformes*	Estrildidae	Indian Silverbill	G	LC	M
67	*Falco naumanni*	FalNau	*Falconiformes*	Falconidae	Lesser Kestrel	C	LC	M
68	*Falco peregrinus*	FalPer	*Falconiformes*	Falconidae	Peregrine Falcon	C	LC	M
69	*Falco subbuteo*	FalSub	*Falconiformes*	Falconidae	Eurasian hobby	C	LC	M
70	*Falco tinnunculus*	FalTin	*Falconiformes*	Falconidae	Common Kestrel	C	LC	R
71	*Ficedula parva*	FicPar	*Passeriformes*	Muscicapidae	Red-breasted Flycatcher	I	LC	M
72	*Francolinus francolinus*	FraFra	*Galliformes*	Phasianidae	Black Francolin	I	LC	R
73	*Francolinus pondicerianus*	FraPon	*Galliformes*	Phasianidae	Grey Francolin	O	LC	R
74	*Fulica atra*	FulAtra	*Gruiformes*	Rallidae	Eurasian Coot	O	LC	M
75	*Galerida cristata*	GalChlo	*Passeriformes*	Alaudidae	Crested Lark	I/ G	LC	M
76	*Gallinago gallinago*	GalCri	*Charadriiformes*	Scolopacidae	Common Snipe	C	LC	M
77	*Gallinula chloropus*	GalGal	*Gruiformes*	Rallidae	Common Moorhen	O	LC	M
78	*Gelochelidon nilotica*	GelNil	*Charadriiformes*	Laridae	Gull-billed Tern	C	LC	M

79	*Glareola pratincola*	GlaPra	*Charadriiformes*	Glareolidae	Collared Pratincole	I	LC	M
80	*Haematopus ostralegus*	HaeOst	*Charadriiformes*	Haematopodidae	Eurasian Oystercatcher	I	LC	M
81	*Himantopus himantopus*	HimHim	*Charadriiformes*	Recurvirostridae	Black-winged Stilt	C	LC	M
82	*Hippolais languida*	HipLan	*Passeriformes*	Acrocephalidae	Upcher's Warbler	I	LC	M
83	*Hirundo rustica*	HirRus	*Passeriformes*	Hirundinidae	Barn Swallow	I	LC	M
84	*Hydroprogne caspia*	HydCas	*Charadriiformes*	Laridae	Caspian Tern	C	LC	M
85	*Ichthyaetus hemprichii*	IchtHem	*Charadriiformes*	Laridae	Sooty Gull	C	LC	M
86	*Iduna pallida*	IduPal	*Passeriformes*	Acrocephalidae	Eastern Olivaceous warbler	I/F	LC	M
87	*Ixobrychus mintus*	IxoMin	*Pelecaniformes*	Ardeidae	Little Bittern	C	LC	M
88	*Lanius collurio*	LanCol	*Passeriformes*	Laniidae	Red-backed Shrike	I	LC	M
89	*Lanius isabellinus*	LanIsa	*Passeriformes*	Laniidae	Isabelline Shrike	I	LC	M
90	*Lanius meridionalis aucheri*	LanMer	*Passeriformes*	Laniidae	Southern grey shrike	I	LC	M
91	*Lanius meridionalis pallidirostris*	LanMer2	*Passeriformes*	Laniidae	Steppe Grey Shrike	I	LC	M
92	*Lanius nubicus*	LanNub	*Passeriformes*	Laniidae	Masked Shrike	I	LC	M
93	*Lanius senator*	LanSen	*Passeriformes*	Laniidae	Woodchat Shrike	I	LC	M
94	*Larus cachinnans*	LarCach	*Charadriiformes*	Laridae	Caspian Gull	C	LC	M
95	*Larus fuscus barabensis*	LarFus1	*Charadriiformes*	Laridae	Lesser Black-backed Gull	C	LC	M
96	*Larus fuscus heuglini*	LarFus2	*Charadriiformes*	Laridae	Lesser Black-backed Gull (Heuglin's)	C	LC	M

97	*Limosa lapponica*	LimLap	*Charadriiformes*	Scolopacidae	Bar-tailed Godwit	I/F	NT	M
98	*Limosa limosa*	LimLim	*Charadriiformes*	Scolopacidae	Black-tailed Godwit	C	LC	M
99	*Luscinia megarhynchos*	LusMeg	*Passeriformes*	Muscicapidae	Common Nightingale	I	LC	M
100	*Luscinia svecica*	LusSve	*Passeriformes*	Muscicapidae	Bluethroat	I	LC	M
101	*Merops apiaster*	MerApi	*Coraciiformes*	Meropidae	European Bee-eater	I	LC	M
102	*Monticola saxatilis*	MonSax	*Passeriformes*	Muscicapidae	Common Rock Thrush	I/ G	LC	M
103	*Monticola solitarius*	MonSol	*Passeriformes*	Muscicapidae	Blue Rock Thrush	O	LC	M
104	*Motacilla alba*	MotAlb	*Passeriformes*	Motacillidae	White Wagtail	I	LC	M
105	*Motacilla cinerea*	MotCin	*Passeriformes*	Motacillidae	Grey Wagtail	I	LC	M
106	*Motacilla citreola*	MotCit	*Passeriformes*	Motacillidae	Citrine Wagtail	I	LC	M
107	*Motacilla flava*	MotFla	*Passeriformes*	Motacillidae	Western Yellow Wagtail	I	LC	M
108	*Muscicapa striata*	MusStr	*Passeriformes*	Muscicapidae	Spotted Flycatcher	I	LC	M
109	*Numenius arquata*	NumArq	*Charadriiformes*	Scolopacidae	Eurasian Curlew	G/I	LC	R
110	*Numenius phaeopus*	NumMel	*Charadriiformes*	Scolopacidae	Whimbrel	C	LC	M
111	*Numida meleagris*	NumPha	*Galliformes*	Numididae	Helmeted Guineafowl	I	LC	R
112	*Nycticorax nycticorax*	NycNyc	*Pelecaniformes*	Ardeidae	Black-crowned Night Heron	C	LC	M
113	*Oena capensis*	OenCap	*Columbiformes*	Columbidae	Namaqua dove	I/ G	LC	M
114	*Oenanthe chrysopygia*	OenChry	*Passeriformes*	Muscicapidae	Red-tailed Wheatear	I	LC	M
115	*Oenanthe deserti*	OenDes	*Passeriformes*	Muscicapidae	Desert Wheatear	I/ G	LC	M

116	*Oenanthe isabellina*	OenIsa	*Passeriformes*	Muscicapidae	Isabelline Wheatear	I	LC	M
117	*Oenanthe oenanthe*	OenOen	*Passeriformes*	Muscicapidae	Northren Wheatear	I	LC	M
118	*Oenanthe pleschanka*	OenPle	*Passeriformes*	Muscicapidae	Pied Wheater	I	LC	M
119	*Onychoprion anaethetus*	OnyAna	*Charadriiformes*	Laridae	Bridled Tern	O	LC	M
120	*Pandion haliaetus*	PanHal	*Accipitriformes*	Pandionidae	Osprey	C	LC	R
121	*Passer domesticus*	PasDom	*Passeriformes*	Passeridae	House Sparrow	O	LC	R
122	*Passer hispaniolensis*	PasHis	*Passeriformes*	Passeridae	Spanish Sparrow	I/ G	LC	M
123	*Pastor roseus*	PasRos	*Passeriformes*	Sturnidae	Rosy Starling	O	LC	M
124	*Pavo cristatus*	PavCri	*Galliformes*	Phasianidae	Indian Peafowl	O	LC	R
125	*Phalacrocorax Carbo*	PhaCar	*Suliformes*	Suliformes	Greater Cormorant	C	LC	M
126	*Phalacrocorax nigrogularis*	PhaNig	*Suliformes*	Suliformes	Socotra Cormorant	C	VU	M
127	*Phoenicopterus roseus*	PhoePh	*Phoenicopteriformes*	Phoenicopteridae	Greater Flamingo	C	LC	M
128	*Phoenicurus phoenicurus*	PhoRos	*Passeriformes*	Muscicapidae	Common Redstart	G/I	LC	M
129	*Phylloscopus collybita*	PhyCol	*Passeriformes*	Phylloscopidae	Common Chifchaff	I	LC	M
130	*Phylloscopus trochilus*	PhyTro	*Passeriformes*	Phylloscopidae	Willow Warbler	I	LC	M
131	*Pluvialis fulva*	PluFul	*Charadriiformes*	Charadriidae	Pacific Golden Plover	I	LC	M
132	*Pluvialis squatarola*	PluSqu	*Charadriiformes*	Charadriidae	Grey Plover	C	LC	M
133	*Prinia gracilis*	PriGra	*Passeriformes*	Cisticolidae	Graceful Prinia	I	LC	M
134	*Psittacula krameri*	PsiCra	*Psittaciformes*	Psittaculidae	Rose-ringed Parakeet	F	LC	R
135	*Pterocles exustus*	PteExu	*Pterocliformes*	Pteroclidae	Chestnut-bellied Sandgrouse	I	LC	M

136	*Ptyonoprogne obsolete*	PtyObs	*Passeriformes*	Hirundinidae	Pale Crag Martin	I	LC	M
137	*Pycnonotus leucotis*	PycLeu	*Passeriformes*	Pycnonotidae	White-eared Bulbul	O	LC	R
138	*Riparia riparia*	RipRip	*Passeriformes*	Hirundinidae	Sand Martin	I	LC	M
139	*Saxicola maurus*	SaxMau	*Passeriformes*	Muscicapidae	Siberian Stonechat	I	LC	M
140	*Saxicola rubetra*	SaxRub	*Passeriformes*	Muscicapidae	Whinchat	I	LC	M
141	*Saxicola rubicola*	SaxRubi	*Passeriformes*	Muscicapidae	European Stonechat	I	LC	M
142	*Spilopelia senegalensis*	SpiSen	*Columbiformes*	Columbidae	Laughing Dove	I/ G	LC	R
143	*Sterna hirundo*	SteHir	*Charadriiformes*	Laridae	Common Tern	C/I	LC	M
144	*Sterna repressa*	SteRep	*Charadriiformes*	Laridae	White-cheeked tern	C	LC	M
145	*Sternula albifrons*	SteAlb	*Charadriiformes*	Laridae	Little Tern	C	LC	M
146	*Streptopelia decaocto*	StrDec	*Columbiformes*	Columbidae	Eurasian Collared Dove	G	LC	R
147	*Streptopelia turtur*	StrTur	*Columbiformes*	Columbidae	European Turtle Dove	F/I	LC	M
148	*Sturnus vulgaris*	StuVul	*Passeriformes*	Sturnidae	Common Starling	O	LC	M
149	*Sylvia atricapilla*	SylAtr	*Passeriformes*	Sylviidae	Eurasian Blackcap	I/F	LC	M
150	*Sylvia communis*	SylCom	*Passeriformes*	Sylviidae	Common Whitethorat	I/ G	LC	M
151	*Sylvia minula*	SylMin	*Passeriformes*	Sylviidae	Desert Whitethroat	I/ G	LC	M
152	*Sylvia mystacea*	SylMys	*Passeriformes*	Sylviidae	Menetries' Warbler	I/F	LC	M
153	*Thalasseus bengalensis*	ThaBen	*Charadriiformes*	Laridae	Lesser Crested Tern	C	LC	M

154	*Thalasseus sandvicensis*	ThaSan	*Charadriiformes*	Laridae	Sandwich Tern	C	LC	M
155	*Tringa erythropus*	TriEry	*Charadriiformes*	Scolopacidae	Spotted Redshank	I	LC	M
156	*Tringa nebularia*	TrinNeb	*Charadriiformes*	Scolopacidae	Common Greenshank	C	LC	M
157	*Tringa ochropus*	TriOchr	*Charadriiformes*	Scolopacidae	Green Sandpiper	C	LC	M
158	*Tringa stagnatilis*	TriSta	*Charadriiformes*	Scolopacidae	Marsh Sandpiper	C	LC	M
159	*Tringa totanus*	TriTot	*Charadriiformes*	Scolopacidae	Common Redshank	I	LC	M
160	*Turdus philomelos*	TurPhi	*Passeriformes*	Turdidae	Song Thrush	O	LC	M
161	*Tyto alba*	TytAlb	*Strigiformes*	Tytonidae	Western Barn Owl	C	LC	R
162	*Upupa epops*	UpuEpo	*Bucerotiformes*	Upupidae	Hoopoe	O	LC	M
163	*Vanellus indicus*	VanInd	*Charadriiformes*	Charadriidae	Red-wattled Lapwing	O	LC	R
164	*Xenus cinereus*	XenCin	*Charadriiformes*	Scolopacidae	Terek Sandpiper	I	LC	M

Appendix II: Some aspects of breeding ecology and threats to Saunders's tern (*Sternula saundersi*) at an offshore island of United Arab Emirates.

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Breeding Behavior and Threats to Saunders's Tern (*Sternula saundersi*) at Sir Bani Yas Island, United Arab Emirates

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Abstract.—The numbers of Saunders's Tern (*Sternula saundersi*) are decreasing globally, and the species' biology remains poorly known. This study used camera traps to determine clutch size, incubation period, hatching and fledging success, and threats to breeding Saunders's Terns on Sir Bani Yas Island, United Arab Emirates. Six nests were selected in each breeding season (12 nests total) from April to June 2017 and 2018 (out of 9 and 8 nests, respectively). The mean clutch size during the two-year period was 1.50 ± 0.22 SE and 1.33 ± 0.21 eggs per nest in 2017 and 2018, respectively. The mean incubation period was 18.97 ± 0.33 days. The mean hatching success was 62.5% in 2017and 45% in 2018. Out of the 12 nests, three nests did not produce any successful chicks, as one nest failed due to predation by feral cats and two due to anthropogenic factors. The monitoring of chicks with camera traps was limited due to their active movement patterns after the third day, but 80-100% of chicks successfully departed nests, and the colony fledged 75-86% of known chicks. *Received 12 November 2019, accepted 29 January 2020.*

Key words.—Breeding success, disturbance, camera traps, incubation period, parental care, predation, Saunders's Tern, *Sternula saundersi*.

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Saunders's Tern (*Sternula saundersi*) is listed as Least Concern (LC) by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (BirdLife-International 2016). It is a small bird that is marginally larger than a swift and has a black bill, outer primaries and head. In breeding plumage, the species has a yellow bill that ends in a black tip and develops a white triangular forehead patch (Aspinall *et al.* 2011). The breeding range of Saunders's Tern includes the United Arab Emirates (UAE), Yemen, Sudan, Somalia, Sri Lanka, Saudi Arabia, Qatar, Pakistan, Oman, Maldives, Bahrain, India, and Madagascar (BirdLife-International 2016). In the UAE, it is a summer and autumn visitor along the eastern coast (Aspinall *et al.* 2011), and in particular, a summer breeder at Sir Bani Yas Island, UAE, where it breeds on the northern and eastern coastline. Saunders's Tern spends winters outside its breeding range (Burger and Gochfeld 1996). Although the species is poorly studied, significant threats that have been reported for Saunders's Tern include predation and anthropogenic factors (Burger and Gochfeld 1996).

Saunders's Tern usually breeds in non-social pairs or may breed in small, loose colonies that range from five to thirty pairs (Burger and Gochfeld 1996). Nests have been recorded up to 2 km inland and are usually small depressions on the bare surface of sand or dried mud. Preferred nesting sites are sand mounds near vegetation (Burger and Gochfeld 1996). Neighboring nests are approximately 20-100 m within these loose colonies. Nests lack any isolation materials (e.g., twigs, grass, and feathers) or cover and are entirely exposed to extreme environmental and ecological stressors. The breeding season usually lasts from March to June, during which both male and female partners participate in the incubation of the eggs (Shobrak and Aloufi 2014; AlRashidi and Shobrak 2015; Burger and Gochfeld 1996).

Breeding success is critical for the maintenance of viable populations. Decreasing trends in the numbers of breeding pairs of Saunders's Tern have been documented globally every year. Studies in Iran in the 1970s and in Bahrain from 1969 to 1981 suggested a substantial decrease in the numbers of breeding pairs (BirdLife-International 2016). This study provides insight into the breeding ecology and threats to breeding pairs of the species, and we assessed the incubation routine, threats and the breeding success of Saunders's Tern on Sir Bani Yas Island, UAE.

Methods

Study Area

Sir Bani Yas Island (24° 18′ 41.04′′ N 52° 35′ 45.24″ E) is considered the largest natural island in the Emirate of Abu Dhabi, UAE. The island is located 180 km southwest of Abu Dhabi and 8 km offshore from the city of Ruwais. Sir Bani Yas Island has arid habitat types (annual rainfall = 150 mm) and a varied topography with small mountains and coastal habitats. The coastal habitat is a mixture of intertidal mudflats, rocky shores, sandy beaches, and mangroves (Dhaheri *et al.* 2017a). It has a total area of 8700 ha, including the 4100 ha Arabian Wildlife Park in the center of the island (Dhaheri *et al.* 2017b).

Saunders's Terns start migrating into the island during March and depart for the winter in September. The primary breeding site was a 1-km coastal patch (a sandy, barren, flat area next to the beach) on the northern side of the island, with a loose colony of an average of twelve to fifteen pairs of Saunders's Tern. However, not all pairs exhibited courtship behaviors or constructed nests. The breeding site was characterized by open sandy gravel with or without scarce *Zygophyllum simplex* vegetation and was near five-star hotel properties with a service road adjacent to the nesting sites.

Data Collection

The study was conducted from April to June of 2017 and 2018. Breeding pairs were counted and monitored using binoculars (Steiner Skyhawk 10x42) and spotting scopes (Yukon 6-100x100; SKU2103IK) during preliminary field surveys to observe the selection of nesting sites. The nests were located, and their GPS locations were recorded (AlRashidi and Shobrak 2015).

One camera trap (ReconyxPC800 Hyperfire Professional IR) was installed approximately 1.5 m from each nest and was camouflaged to avoid distress to the birds (AlRashidi and Shobrak 2015). During camera installation, egg morphometrics were recorded carefully with a Vernier caliper without disturbing the nest. Cameras were programmed to take five photographs at an interval of one second after every detected movement. Date, time, and ambient temperature were recorded with each photograph. The night vision capacity of the cameras enabled monitoring of incubation activities even during the night. Incubation bout durations were determined using photographs to determine initiation and cessation times of each bout by a parent. The clutch size and number of hatchlings were recorded. After hatching, the duration of parental care of the chicks was recorded in minutes from beginning to end through photographs. Activities recorded under parental care included feeding chicks, brooding, chicks resting in the nest, and latent learning. Such behaviors were recorded for a maximum duration of 96 h after the last hatchling. Chicks could not be further monitored after this period due to their high mobility and frequent movement outside of the camera range. The mean time spent in each activity were then calculated for day and night. The photographs from the camera traps assisted in the detection of the total days of incubation and egg hatching success or failure of the nest.

Data Analysis

The density of nesting pairs at the breeding site was calculated by dividing the number of nesting pairs by the area of the breeding site. The fledging period was determined as the number of days from the hatching of the first eggs until chicks were able to fly in the colony. The disturbance frequency was calculated by counting the number of times the birds were disturbed out of the nests due to the movement of vehicles through the photographs.

Correlations between hatching success and the distances of nests from the sea and service road were analyzed using Minitab® 18.1 (Minitab Inc., Pennsylvania, United States). Hatching success was calculated as the percentage of eggs that successfully hatched, and chick success was calculated as percentage of hatchlings that successfully left nests. Colony fledging success was calculated as the percentage of known chicks that successfully fledged (observed flying in the colony). Means are reported ± SE.

The diurnality index of the parental care activities, such as feeding, the time spent by the chicks under the wings of the parents, and exploration and resting by the chick in the presence and absence of parents, were calculated using the formula (Hoogenboom *et al.* 1984):

$$\text{Diurnality index} = (cd / td - cn / tn) / (cd / td + cn / tn)$$

Where cd = sum of the activity values during the day; cn = sum of the activity values during the night; td = numbers of sample intervals during the day; and tn = numbers of sample intervals during the night. The resulting value of the diurnality index is from -1 to +1; negative values suggest nocturnal activity, positive values suggest diurnal activity, and a value of 0 suggests similar proportions of nocturnal and diurnal activities.

Results

We analyzed 51,942 photographs from 12 (71%) of 17 total nests (Table 1). Density of breeding pairs was 0.94 pairs/ha in 2017 and 0.68 pairs/ha in 2018 (nest area in Table 1). Nest initiation and first egg-laying occurred in the first week of April. The eggs were pale

Table 1. Breeding performance of Saunders's Terns (*Sternula saundersi*) at Sir Bani Yas Island, UAE, April-June 2017 and 2018 (mean ± SE). Differences between neighboring nests were significantly larger in 2018 than in 2017 (Mann-Whitney test, $P < 0.05$); no other differences between 2017 and 2018 were statistically significant.

Parameter	2017	2018
Nesting area (ha)	11.7	11.7
Number of nests	9[a]	8
Nests studied	6	6
Distance from sea (m)	56 ± 10	76 ± 15
Distance from service road (m)	28 ± 8	40 ± 12
Distance from nearest neighboring nest (m)	28 ± 5	60 ± 6
Clutch size (eggs)	1.33 ± 0.21	1.50 ± 0.22
Egg length (mm)	32.1 ± 0.16	32.1 ± 0.08
Egg breadth (mm)	23.9 ± 0.08	24.0 ± 0.05
Incubation period (A-egg) (d)	19.2 ± 0.45	18.8 ± 0.51
Hatching success (% of eggs)	62.5	45
Chick success (% of chicks departing nests)	80	100
Fledging period (d)	25.6 ± 3.7	27.2 ± 1.4
Colony fledging success (% of known chicks)	75	86

[a]Excluding two nests deserted soon after nest construction

colored with dark brownish spots for camouflage. Nests were nearer the sea and service road in 2017, and egg measurements were consistent between years (Table 1).

The mean clutch size was 1.50 ± 0.22 and 1.33 ± 0.21 eggs per nest in 2017 and 2018, respectively (Table 1). The mean incubation period was 18.97 ± 0.33 days (Table 1). The mean hatching success was 62.5% in 2017 and 45% in 2018, and 80-100% of chicks successfully departed nests (Table 1). The colony fledged 75-86% of known chicks (Table 1). There were no significant correlations between hatching success and distance from sea ($r = -0.540$, $P = 0.070$), service road ($r = 0.132$, $P = 0.682$), nor neighboring nests ($r = -0.160$, $P = 0.618$).

The diurnality indices indicated a slight bias of most observed behaviors as occurring more diurnally, except for incubation and chicks resting (Table 2). There was a statistically significant difference in the incubation routine between day and night ($Z = 3.05$, $P = 0.0022$), and the diurnality index indicated a greater incidence of incubation at night (Table 2). The birds incubated more during the night compared to during the mid-day periods, and both parents were involved in incubation, although it was not possible to differentiate between sexes as there is no sexual dimorphism in Saunders's Tern. Nocturnally-biased behaviors were also associated with lower average temperatures compared to most other behaviors (Table 3).

During the mid-day period, when the birds were not incubating nests, they appeared to fly over the nests, and photographs revealed the slight movement of the eggs presumably due to the wind created by such low flights. During mid-day periods, parents either alternated foraging or both left the nest unattended to forage. In two cases, the eggs went > 20 h without incubation just one to three days before hatching. Parenting was conducted by both parents who, on the first three days during the peak forage time (mid-day), returned to the nest with a fish within 10 to 15 minutes. Once a

Table 2. Diurnality Index of different activities of Saunders's Terns (*Sternula saundersi*) at Sir Bani Yas Island, UAE, April-June 2017 and 2018. Negative values indicate behaviors occurring more often or longer at night and positive values indicate those that are diurnal.

Behavior	Diurnality Index
Disturbance	0.41
Feeding by parents	0.79
Parental care	0.91
Incubation	-0.12
Flying over nest	0.42
Feeding by chicks	0.82
Brooding	0.88
Latent learning w/parents	0.93
Latent learning wo/parents	0.68
Resting in absence of parents	-0.52

Table 3. Ambient temperatures in relation to different activities of Saunders's Terns (*Sternula saundersi*) at Sir Bani Yas Island, UAE, April-June 2017 and 2018.

	Temperature (°C)		
Behavior	Average	Min.	Max.
Incubation	33.7 ± 0.6	29.8	38.9
Feeding (parents)	35.9 ± 0.9	30.1	38.9
Parental care	35.8 ± 0.7	30.1	38.9
Flying over nest	35.7 ± 1.3	29.8	38.9
Feeding by chicks	37.5 ± 0.9	33.8	39.9
Brooding	36.7 ± 0.7	33.4	39.9
Latent learning w/parents	30.8 ± 0.6	29.8	34.5
Latent learning wo/parents	33.8 ± 0.7	30.1	35.6
Resting in absence of parents	31.7 ± 0.7	28.8	36.9

parent came to a chick with a fish, the other parent flew away to hunt and bring food to the growing chicks.

Out of twelve nests we monitored, three nests failed completely. The data from the camera traps revealed that one nest failed due to predation by feral cats, while two nests failed due to anthropological factors (movement of vehicles and vehicle noise). At the nests that failed due to anthropological factors, the mean disturbance (by vehicles passing by) of failed nests was substantially higher (52 ± 2 times per day) in comparison to the successful nests (5.6 ± 0.2 times per day).

Discussion

Saunders's Tern preferred coastal areas with scarce vegetation for nest sites. Similarly, the closely related Little Tern (*Sternula albifrons*) and Least Tern (*Sternula antillarum*) prefer open, sandy beaches and islands as their breeding sites (Oro *et al.* 2004; Thompson *et al.* 1997). According to a study on the biology of Little Tern, 63% of nesting colonies were on beaches (Oro *et al.* 2004). The nest of Saunders's Tern is a depression in the ground, similar to the Little Tern and Least Tern (Oro *et al.* 2004; Thompson *et al.* 1997). In the current study, Saunders's Terns were found in loose colonies, similar to Little Tern and Least Tern that form colonies up to 30 pairs (Massey 1977; Oro *et al.* 2004). However, not all birds in the colonies breed (Fraser 2017). In the current study, the pairs involved in breeding were almost half of the colony, while the remainder were nonbreeders.

Our mean clutch size for Saunders's Tern was lower compared to the mean clutch size of 2-3 eggs in Least Tern and Little Tern (Thompson *et al.* 1997; Fraser 2017; Pakanen *et al.* 2014). There are no previously reported egg measurements for Saunders's Tern to compare with our results. Egg size may indicate the health of the breeding pair, quality of habitat and abundance of food, and may also affect the hatching success (Oro *et al.* 2004). In Little Tern and Least Tern, second and third attempts to breed after prior nest failure (replacement nests) in the same breeding season have been reported, however, clutch size was usually reduced to 1-2 eggs (Fraser 2017). Pakanen (2014) reported 54% replacement nests in Little Tern. It may be hypothesized that replacement nests can be an attempt to increase breeding success of the colony. However, no hatchlings were recorded by Pakanen (2014) out of replacement nests.

Both Saunders's Tern parents were observed incubating eggs, similar to Little Tern and Least Tern (AlRashidi and Shobrak 2005; Thompson *et al.* 1997). In our study, the duration of the incubation period was similar to the reported incubation period of 17-22 days in Little Tern (Fraser 2017). During the incubation phase, parents take on the costs of the survival of their eggs and maintain an optimal temperature for chick growth. These costs include loss of foraging time and risk of exposure to predators. Moreover, they must combat harsh weather conditions to protect the growing embryos in the eggs. The optimal temperature for many bird species during incubation is 36-40.5°C. Timing of the breeding season is thus a critical factor to the breeding success and is an adaptation to avoid extreme climatic conditions of the year (AlRashidi and Shobrak 2015). The recorded temperatures during the breeding season on Sir Bani Yas Island were between 28.8-39.9°C. However, the temperature may rise to near 50°C later during the year.

The diurnality index in our study suggests that the Saunders's Tern incubated more during the night compared to the day times, possibly to cope with lower temperatures during the night. AlRashidi and Shobrak (2015) reported Saunders's Tern incubated more when the ambient temperatures were near or below 25 °C (as temperature below 25 °C can be lethal for the embryo) and incubated less when temperatures were high. Moreover, they observed less incubation during morning and evening, which could be associated with peak foraging times for the parents or increased activity of predators. Saunders's Tern are pugnacious and defend their nest from predators. Similar behavior is also reported for Least Tern (Thompson *et al.* 1997). Parents were observed flying aggressively over the nest in our study and by AlRashidi and Shobrak (2005), an adaptive behavior to deter predators.

If Saunders's Terns anticipate high predation risk or extreme daytime temperatures are intolerable, they may abandon their eggs during incubation (Amat and Masero 2004). Similar behavior is reported in Little Tern, abandoning their eggs if there is disturbance or heavy rain (Pakanen 2014). Predation is one of the major threats to the breeding success of terns. In our study, nest predation by cats was one of the contributing factors to nest failure. Similarly, predators such as gulls, dogs, and ravens have been reported to affect breeding success of Little Tern and Least Tern (Thompson *et al.* 1997; Swickard 1972). Pakanen (2014) reported 60% of nest failure in Little Tern was due to predation. In our study, chicks moved around in the breeding site, usually staying close to rocks or plants for cover. The same behavior is reported in the chicks of other tern species (Oro *et al.* 2004; Thompson *et al.* 1997), which demonstrate escape behavior in response to any threat, covering dozens of meters and seeking immediate cover. Chick mortality is reported due to abandonment by the parents, starvation, and exposure to extreme weather conditions in Least Tern (Swickard 1972). The mean fledgling survival rate was higher in our study compared to the mean fledging rate of 45% in Little Tern (Fraser 2017). Swickard (1972) reported 56-74% mortality rate from hatchling to fledgling for Least Tern.

Our results provide details on the nesting biology of Saunders's Tern, adding valuable knowledge about a poorly studied species and revealing similarities with its congeners as would be expected. The deployment of a higher number of camera traps in future years around breeding sites could provide more insight into the nesting biology and identify threats to the species. Therefore, we recommend further studies to extensively cover these limitations and to provide deeper insight into the breeding success of this species.

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Appendix III: Determining population trend and breeding biology of Common Kestrel (*Falco tinnunculus*) at Sir Bani Yas Island of Emirates.

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DETERMINING POPULATION TREND AND BREEDING BIOLOGY OF COMMON KESTREL (*FALCO TINNUNCULUS*) AT SIR BANI YAS ISLAND OF EMIRATES

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ABSTRACT

Successful breeding is associated with propagation and well-being of the species and requires a healthy and intact ecosystem. However, to analyse these effects, the knowledge of the natural behaviours and variations in the breeding biology of the birds is essential. Common kestrel (*Falco tinnunculus*) is widely distributed in Asia, Africa and Europe. The current study was designed to evaluate the population trends and breeding success of common kestrel in Sir Bani Yas Island from 2014-2018, and to provide an insight to the survival of this species in a restored habitat. Population of common kestrel was monitored through line transect method by categorising it into three habitat types *viz*. Mountains, Forests, and Pastures/open area. In each habitat category, two transects of 2,000 meters length and 200 meters width on each side were laid. The population data from three habitat types showed statistically significant difference in preference of habitat types (H-Value = 27.43, DF = 2, P-Value = 0.0000011). The birds showed preference of open/pasture habitats in non-breeding season and mountains during breeding season. The courtship and nesting started during early April and the eggs were laid during late April. The average clutch size was 3.75 ± 0.31 eggs per clutch. The average incubation period was 29.13 ± 0.52 days resulting in average hatchlings of 3.50 ± 0.53 chicks. The eggs were incubated 74.02 ± 1.69 % and were unattended for 24.54 ± 1.64 % of the total incubation period. The finding of this study can be used as future reference to study the breeding success of the species and provide cues for further improvement of the ecosystem conditions by improving the habitat condition on the Island based ecosystems.

Key words: Afforestation, Apex predators, Breeding Behaviour, Common Kestrel, Ecological health

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INTRODUCTION

Aves are one of the principal classes of vertebrates, surrogated as ecological health indicators. They assist in the assessment of changes in the ecosystem, ecological health, and effects and risks to the ecological set up by climate change and anthropogenic activities (O'Connell *et al.,* 2007). Birds of prey can endorse increased biodiversity by both facilitation of resources and making them available to species that could not otherwise avail them, and by trophic cascades, i.e. by affecting the trophic levels (Sergio *et al.,* 2008). Top predators are used as conservation tools and are very effective to determine ecological health (Ronka *et al.,* 2011).

Successful breeding is regarded as an indicator of a healthy and intact ecosystem; any changes in breeding success can immediately provide cues for degrading ecological health that can be a result of environmental changes or anthropogenic catastrophes (Ronka *et al.,* 2011). However, to analyse these effects and aim the interpretations towards the conservation and management interventions, the knowledge of the natural behaviours and variations in the breeding biology of the birds is essential (Ronka *et al.,* 2011).

The reproductive success is influenced by many factors such as photoperiod, availability of food during the breeding season, climate conditions, geographic variation of the breeding areas, presence or absence of predators, as well as the extent of human disturbance. All these factors may affect the onset of the courtship, egg laying, clutch size and fledging success in a given ecological set up (Bustamante and Rodriguez, 2003; Carrillo and Gonzalez-Davila, 2010; Vasko *et al.,* 2011).

Common kestrel (*Falco tinnunculus*) belongs to family Falconidae and is listed as Least Concern (LC) in Red List of Threatened Species by IUCN (BirdLife-International, 2016). In the United Arab Emirates (UAE) it is winter visitor and passage migrant with some resident populations (Aspinall *et al.,* 2011). Common kestrel prefers mountainous and rocky areas but is also found in deserts, forests, farmlands, towns and gardens (Anushiravani and Roshan, 2017a; Aspinall *et al.,* 2011).

The breeding pairs usually select cliff, tree cavities, crags, poles, artificial nesting boxes or sometimes building structures; they are also known to usurp nests from other species (Anushiravani and Roshan, 2017a; Hustler, 1983). The reported start of the courtship and nest selection is late March, and egg laying starts between late April and early May with an average clutch size of 3-6 eggs (Massemin *et al.,* 2002; Valkama *et al.,* 2002). The incubation in common kestrel is reported to be between 27-31 days; and the average fledging period is 27-39 days (Valkama *et al.,* 2002; Anushiravani and Roshan, 2017a).

Sir Bani Yas Island was developed as a wildlife reserve for the conservation of endangered species. The island was transformed from barren, arid land to suitable habitat for more than 160 migratory and resident bird species by the plantation of more than two million trees (Mehmood *et al.,* 2014). The abundance of prey species started attracting many raptors including eagles, falcons, harriers, osprey and kestrel. As discussed earlier, to assess the ecological health by surrogating birds of prey, it is imperative to note their behaviours, population trends and breeding pattern over the period to be able to infer the signals of a requirement of conservation intervention. There is no reported study on the breeding of common kestrel in UAE and in Sir Bani Yas Island. The current study was designed to evaluate the population trends and breeding success of common kestrel in Sir Bani Yas Island and to provide an insight to the survival of this species in a restored habitat and to serve as a guideline for further studies and management interventions regarding the conservation of these apex predators.

MATERIALS AND METHODS

Study Area: Sir Bani Yas Island is regarded as the largest natural island in the Emirate of Abu Dhabi, UAE (Figure 1). It is 180 km south-west of Abu Dhabi city and 8 km offshore with a total area of 87km² (Kabeer *et al*., 2020).The island is declared as a protected area for conservation of endangered and indeginous fauna and flora (Mehmood *et al.,* 2014). The detailed description of the study area is presented in Table 1.

Data Collection: Population and breeding success of common kestrel was studied from January 2014 till December 2018. Population of common kestrel was monitored through line transect method monthly (Sutherland *et al.,* 2004). The island was categorised into three habitat types viz. Mountains, Forests, and Pastures/open land. In each habitat category, two transects were laid; each transect was 2,000 meters long and 200 meters wide on each side (L = 2,000 m; W = 400 m) (Anwar *et al.,* 2015). Each transect was visited once a month. Two transects were at least 1,000 meters apart from each other. A pair of binoculars (Steiner Skyhawk 10x42) and a camera (Nikon DSLR 3200 with 400 mm lens) was used to identify and record the birds (Anwar *et al.* 2015). The species identification was verified through field guide "Birds of the United Arab Emirates - A guide to common and important species (Aspinall *et al.,* 2011).

The birds were observed to identify their nesting sites. Once located, the nests were identified and their locations were recorded (AlRashidi and Shobrak, 2015). To monitor breeding activities, each nest was monitored early morning (7 to 8 am), afternoon (12-1 pm) and late evening (4:30 to 5:30 pm) for one hour each (three hours per day). The observation time and activities were limited to avoid disturbance and undue stress to the nesting birds. The team was properly camouflaged while monitoring the nests with binoculars. Each monitoring was done by a team of two observers. During 2017 and 2018, multiple teams were used to collect breeding data due to additional nests. The incubation and fledging periods were recorded. Moreover, clutch size, number of hatchlings, and number of fledglings were also recorded for each nest. Other parameters such as the times where parents were feeding the chicks, and chicks with and without parents were also recorded (Antonov *et al.,* 2007; Poirazidis *et al.,* 2009).

Statistical Analysis: The population and habitat selection parameters were subjected to Kruskal-Wallis H Test using Minitab® 18 statistical software. Hatching success percentage was calculated by dividing number of hatchlings with the clutch size; the fledging success percentage was calculated by dividing number of fledglings with the number of hatchlings. Additionally, the survival rate percentage was calculated by dividing the number of successful fledglings with the clutch size (Antonov *et al.,* 2007).

RESULTS

The population (mean ± SE) was 8.17 ± 0.60, 9.75 ± 0.55, 10.50 ± 0.56, 12.42 ± 0.84, and 16.67 ± 1.50 individuals during 2014, 2015, 2016, 2017, and 2018 respectively. Kruskal-Wallis Test confirmed a statistically significant difference (H-Value = 22.07, DF = 4, P-Value = 0.00019) in the populations over the course of five years i.e. from 2014 – 2018 (Figure 2). The higher population density was from April to September (Figure 3).

The population data from three habitat types showed statistically significant difference (Kruskal-Wallis Test) in preference of habitat types (H-Value = 27.43, DF = 2, P-Value = 0.0000011) (Figure 4). The mean population during each year in different habitat categories is presented in table 2. The birds showed clear preference of open/pasture habitats, especially for feeding. They used to select a vantage point such as a tree top or a pole and search for prey from it. In breeding season, they chose mountains.

During the study period total eight nests were monitored. Common kestrel on Sir Bani Yas Island preferred small crevices or cavities on vertical cliffs of the mountains (87.5 %) about 12-15 feet above ground or on the top of high tower (12.5 %) more than 100 meters high. The average height of the nest was 31.81 cm with an average width of 25.70 cm. The birds also preferred same nesting sites used during previous breeding season. Common kestrel started courtship and nesting during early April and the egg laying started during late April. The average clutch size was 3.75 ± 0.31 eggs with a range of 2-5 eggs per clutch. The average incubation period was 29.13 ± 0.52 days (range = 27-31 days); resulting in average hatchlings of 3.50 ± 0.53 chicks. The hatching and fledging success are given in table 3. All the hatchlings successfully fledged the nest. Only one nest failed and yielded no hatchlings. The mean fledging period was 35.63 ± 5.16 days (range = 37 – 45 days).

The eggs were incubated 74.02 ± 1.69 percent of the total incubation period. The incubation was mostly by female, where male would incubate during her absence only and for shorter durations. While they were unattended 24.54 ± 1.64 percent of the total incubation duration (Table 4). Parents spent 1.44 percent time feeding in the nests, where male would bring food for the female. During the total fledging period, 68.22 ± 0.46 percent time the parents attended the chicks; whereas, the chicks were unattended in the nests 28.09 ± 0.43 percent of the time and 3.69 ± 0.16 percent of the fledging period was spent by chicks on feeding (Figure 5). The hunting technique varied during breeding and non-breeding season, as common kestrel used flight-hunting as major hunting technique during breeding season, whereas, they used both flight and perch-hunting techniques during non-breeding season.

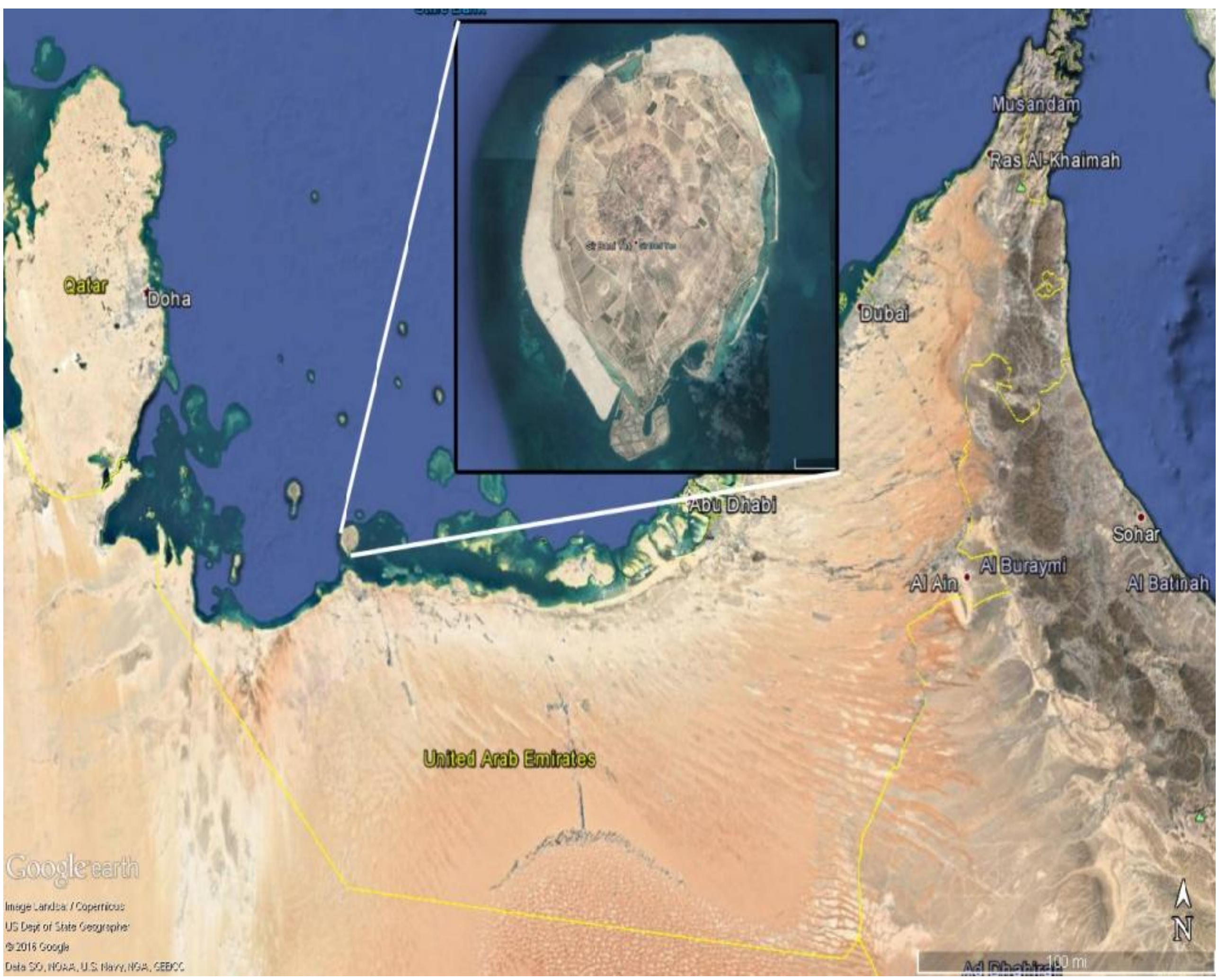

Fig. 1. Map of Sir Bani Yas Island, UAE, for breeding success study of Common kestrel (*Falco tinnunculus*)

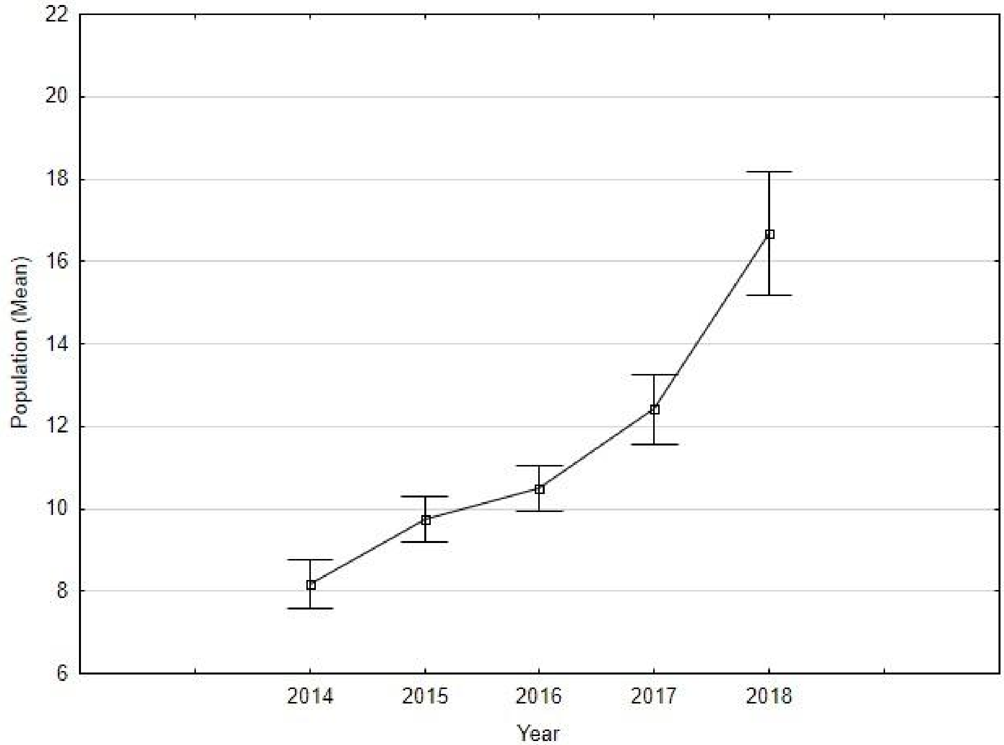

Fig. 2. Yearly population trend of Common kestrel (*Falco tinnunculus*) from 2014-2018 at Sir Bani Yas Island, United Arab Emirates

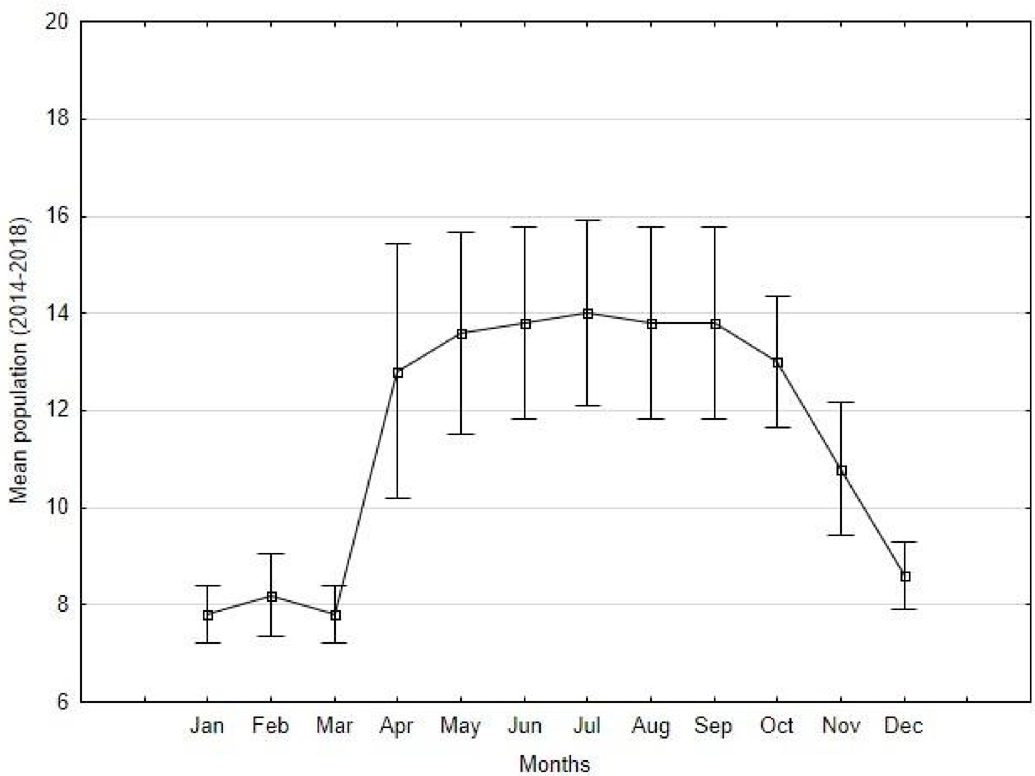

Fig. 3. Monthly population trend of Common kestrel (*Falco tinnunculus*) from 2014-2018 at Sir Bani Yas Island, United Arab Emirates

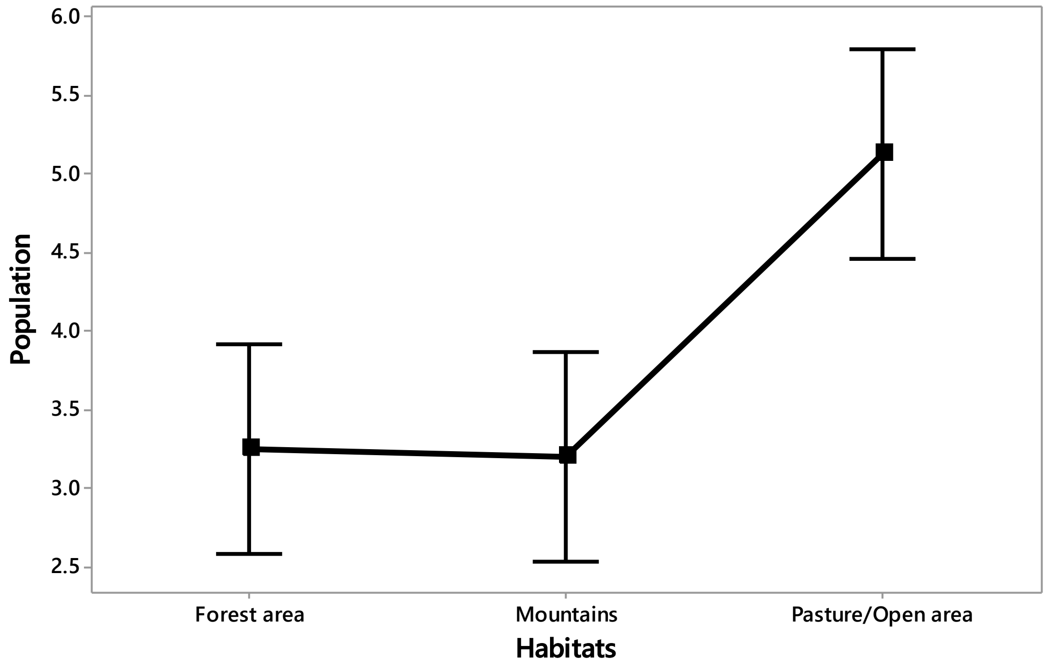

Fig. 4. Population trend of Common kestrel (*Falco tinnunculus*) in different habitat types from 2014-2018 at Sir Bani Yas Island, United Arab Emirates

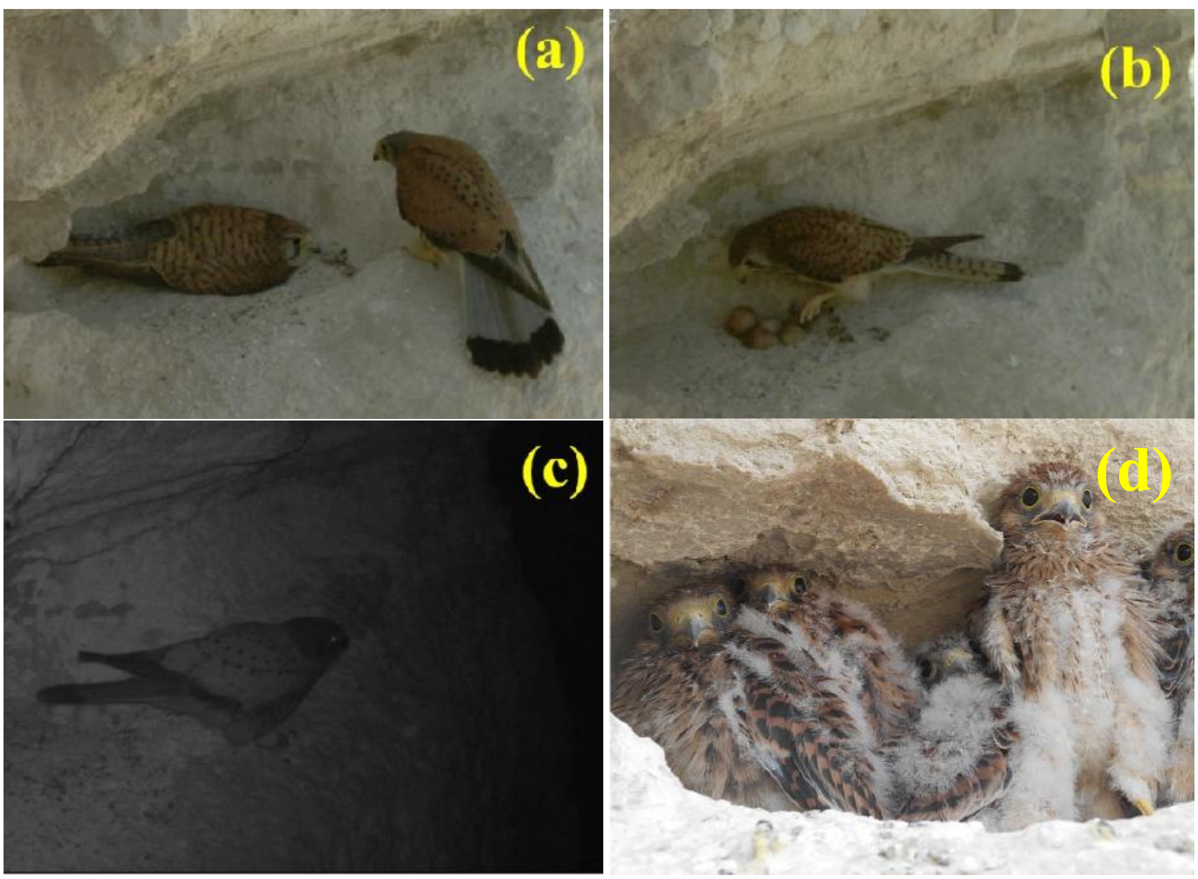

Fig. 5. Photographs of Common kestrel (*Falco tinnunculus*) at Sir Bani Yas Island, United Arab Emirates (a) presence of both parents at nest (b) female turning eggs during incubation (c) female during incubation at night (d) chicks in the nest waiting for parents to bring food

Table 1. Description of the area (Sir Bani Yas Island, UAE) for breeding success study of Common kestrel (*Falco tinnunculus*) (Mehmood *et al*. 2014).

S.	Parameters	Description
1	Total Area	*8,700 ha*
2	Area of Arabian Wildlife Park (AWP)	*4,100 ha*
3	Coordinates	*24°20' N; 52°36' E*
4	Avg. temp	*18.1-35.8 º C*
5	Annual rainfall/year	*54.97 – 119.04 mm*
6	Avg. humidity	*26.3% - 56.6%*
7	Total number of animals	*16,000*
8	Total trees planted	*> 2 million*
9	Total number of birds' species	*165*

Table 2. Mean population of Common kestrel (*Falco tinnunculus*) during the study period at Sir Bani Yas Island, United Arab Emirates.

Year	Population Mean ± SE in Different Habitat Types		
	Mountains	**Forest area**	**Pasture/Open area**
2014	2.17 ± 0.51	2.58 ± 0.31	3.42 ± 0.53
2015	2.25 ± 0.60	3.08 ± 0.23	4.42 ± 0.42
2016	2.50 ± 0.63	3.08 ± 0.31	5.08 ± 0.56
2017	3.17 ± 0.81	3.33 ± 0.48	5.92 ± 0.79
2018	5.92 ± 1.46	4.17 ± 0.82	6.83 ± 1.11

Table 3. Breeding success of Common kestrel (*Falco tinnunculus*) during the study period at Sir Bani Yas Island, United Arab Emirates.

Breeding Success Variables	Value
Number of Nests	**8**
Average Clutch size (Numbers)	**3.75 ± 0.31**
Average number of hatchlings	**3.50 ± 0.53**
Average number of fledglings	**3.50 ± 0.53**
Hatching Success (Percentage)	**87.50 ± 12.50**
Fledging success (Percentage)	**100.0 ± 0.00**
Total Nests Failed (Numbers)	**1**

Table 4. Incubation and Parenting routine of Common kestrel (*Falco tinnunculus*) during the study period at Sir Bani Yas Island, United Arab Emirates.

Incubation and Parenting Variables	Value (Mean ± SE)
Total incubation period	**29.13 ± 0.52 Days**
Time for eggs incubation by parents during incubation period	**74.02 ± 1.69 %**
Feeding time by parents during incubation	**1.44 ± 0.13 %**
Time during incubation while eggs were unattended	**24.54 ± 1.64 %**
Total fledging period	**35.63 ± 5.16 Days**
Time Chicks were attended by parents during fledging period	**59.70 ± 8.54 %**
Time Chicks were unattended by parents during fledging period	**24.57 ± 3.53 %**
Time chicks were fed during fledging period	**3.23 ± 0.48 %**

DISCUSSION

The population trend, habitat preference and breeding success of the common kestrel were studied first time on Sir Bani Yas Island. Birds of prey can impact the bird diversity of an area by regulating the resources and controlling the prey populations (Sergio *et al.,* 2008).

The results of current study show a steadily establishing population of common kestrel on Sir Bani Yas Island. The increase in population suggests abundance of resources (such as shelter and prey) on the island and the success of the extensive afforestation efforts to create a suitable habitat for endangered, resident and migratory fauna on the island (O'Connell *et al.,* 2007). There was a surge in population from late April until September on the island. The population was higher during these months due to addition of hatchlings and later declined when the fledglings dispersed out of the island in October.

Common kestrel preferred habitats with pastures and open areas during non-breeding season and for predation. This could be attributed to the abundance of the prey and clear vantage to search their prey species. During breeding season, the birds preferred nesting in mountainous habitats. This preference can be due to the safety and privacy of the nests and chicks (Roberts, 1991). The preferred habitat of common kestrel coincides with our findings; as they are reported to exist in mountainous areas, forests, farmland and pastures (Anushiravani and Roshan 2017a; Aspinall *et al.,* 2011: Casagrande *et al*., 2008).

The gradually establishing population and successful breeding of common kestrel on Sir Bani Yas Island also indicates the good health of the ecosystem as successful breeding is directly proportional to the ecological health (Ronka *et al.,* 2011). The preference of nesting site was for small crevices and cavities in the mountainous areas. Other studies also suggest that common kestrels prefer cliffs as nesting sites but are also found to nest on artificial structures and even nest boxes (Shrubb, 1993). The average nest dimensions of common kestrel nests were higher than the dimensions in studies from (Anushiravani and Roshan, 2017) who reported the nest dimensions from 32 sites to be 19.7 x 21.9 cm. However, this could be dependent on the availability of the good nesting sites, as the pair was not observed to expand the nests or to alter them significantly from their original condition.

The average clutch size in the current study was within the described range of 3-6 eggs (Massemin *et al.,* 2002; Valkama *et al.,* 2002); but the mean clutch size was lower as compared to 5.03 ± 0.7 eggs in a study conducted in Iran (Anushiravani and Roshan, 2017a). Only one nest had a lower clutch size of two eggs and was the only nest that failed to produce any hatchlings. Due to failure of one nest the hatching success dropped to 87.50 ± 12.50 percent; as all other nests had 100% hatching rate. Due to abundant food supply and critical nesting site selection, the fledging success was cent per cent. The hatching rate (87.50 %) was higher in our study compared to 84.4% reported in Iran along with the fledging rate which was previously reported as 73.9% (Anushiravani and Roshan., 2017a).

The incubation period in the current study coincided with the previous studies ranging from 27 – 31 days; the average fledging period in the current study was similar to the previous studies on common kestrel (Anushiravani and Roshan, 2017a; Charter *et al.,* 2008; Valkama *et al.,* 2002).

The eggs were incubated 75% of the total incubation period and were left unattended 25% of the time during incubation period. Due to the choice of nesting site, there was no threat to the unattended eggs or chicks (unattended in the nest about 28% of total fledging period). All the nests were inaccessible to humans, predators or other animals. However, in the failed nest there were pugmarks of rock hyrax (*Procavia capensis*) near the nest. We could not establish a link of rock hyrax presence to the failure of the nest; due to absence of concrete evidence.

The male brought food for female 1.44% of the incubation time when female did not leave the nest for feeding; the male would bring food to the female. Mostly the prey species brought by the male were ocellated skink (*Chalcides ocellatus*), gecko species, gerbil species, parts of rock pigeon (*Columba livia*) and grey francolin (*Francolinus pondicerianus*). There were also many other prey items that could not be identified with binocular. Various studies have reported 49 prey items (Charter *et al.,* 2008) 172 prey items (Anushiravani and Roshan, 2017b) and 349 prey items (Gao *et al.,* 2009) for common kestrel during breeding season. Considering the abundance of prey species, safe nesting sites and successful breeding; it is indicative that the ecological health at Sir Bani Yas Island is in favour of biodiversity, especially propagation of raptors.

Successful breeding and healthy population is regarded as an indicator of a healthy and intact ecosystem; any decline in breeding success and population can immediately provide cues for degrading ecological health that can be a result of environmental changes or anthropogenic catastrophes. This could be attributed to the presence of the prey and clear vantage to search their prey species. Common kestrel started courtship and nesting during early April and the egg laying started during late April. Both parents take part in incubation and rearing of chicks. Male was more involved in hunting and feeding operations for the female and chicks.

Conclusion: The increase in population of Eurasian Kestrel during the study period suggests abundance of resources on the island and the success of the extensive afforestation efforts to create a suitable habitat. The bird prefers pastures and open areas during non-breeding season and for predation. The finding of this study could be used as future reference to study the breeding success of the species and provide cues for further improvement of the ecosystem conditions by improving the habitat condition at the Island. However, the observations on incubation and parental care can be further studied using camera traps to have concrete information on nest failure.

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Appendix IV: Breeding of the Osprey, (*Pandion haliaetus*) in natural and artificial nesting substrates in the United Arab Emirates (Aves: Accipitriformes).

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SHORT COMMUNICATION

Breeding of the Osprey, *Pandion haliaetus,* in natural and artificial nesting substrates in the United Arab Emirates (Aves: Accipitriformes)

Bilal Kabeer[a,b,*], Sadaf Bilal[a], Sadia Abid[a], Pavla Hejcmanová[a], Muhammad Arslan Asadi[b], Muhammad Jawad Jilani[b] and Abid Mehmood[a,b]

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The Osprey (*Pandion haliaetus*) has a cosmopolitan distribution and it is a not rare breeder in some coastal areas in the United Arab Emirates, Bahrain, and Oman in the Arabian Gulf region (Jennings, 2010; Khan, Javed, & Shah, 2008). The species is predominantly a ground nester in Arabia, but it also takes advantage of human-made constructions such as abandoned buildings or electricity pylons (Jennings, 2010). Artificial nesting platforms have been installed in the United Arab Emirates to aid reproduction and to overcome a lack of a sufficient number of suitable nesting sites. Nest platforms are known to have a positive effect on the breeding productivity of Ospreys and other raptors (Brown & Collopy, 2008; Hunt et al., 2013). The current study therefore compares the breeding success of a small population of Ospreys on the mainland and on the neighbouring island and evaluates the efficency of artificial nesting platforms which have been established to enhance breeding success.

The study was conducted at two locations in the western region of Abu Dhabi, United Arab Emirates. The first location was Sir Bani Yas Island that has a total area of 87 km² and was developed and defined as a protected wildlife reserve. Initially, the island consisted of barren arid land, and according to the master plan for its development, more than two million trees were planted to provide a suitable habitat for endangered fauna, especially for bird species on the island (Dhaheri et al., 2017). The second study site was 4600 ha forest, located 350 km from Abu Dhabi and is one of the protected areas near Al Sila city.

Every year from 2014 to 2019, both study areas were surveyed to locate nests. All active nests were marked using a handheld GPS unit (Garmin, etrex) and information such as nest height, diameter, material used in nest construction, altitude from sea level, distance from nearest human establishment, paved and unpaved roads was recorded using measuring tape (Ali, Mahmoud, & Elamin, 2015). Nest type was assigned either as natural nests if the nests were on any naturally occurring structure (i.e. rock, ground or tree) or artificial nesting platform if the nest was on a human-made platform (Khan et al., 2008).

A total of nine natural nests were observed in Al Sila, and three natural and five nests on platforms in Sir Bani Yas Island (Table 1). These platforms were constructed at

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Table 1. Nest types, hatching and breeding success of Osprey (*Pandion haliaetus*) on mainland and Sir Bani Yas Island in the United Arab Emirates.

Location	Nest Type	Nest ID	Year	No of Eggs	No of hatchlings	No of fledgelings	Hatching Success	Fledging success
Al Sila	Natural: mainland	ASN-1	2014	3	3	3	100.0	100.0
		ASN-2	2015	2	2	2	100.0	100.0
		ASN-3	2015	3	2	2	66.7	100.0
		ASN-4	2016	3	3	2	100.0	66.7
		ASN-5	2017	3	2	2	66.7	100.0
		ASN-6	2017	2	2	1	100.0	50.0
		ASN-7	2018	3	3	2	100.0	66.7
		ASN-8	2018	3	1	1	33.3	100.0
		ASN-9	2019	3	3	3	100.0	100.0
SBY	Natural: island	NNS-1	2014	3	2	0	66.7	0.0
		NNS-2	2015	0	0	0	0.0	0.0
		NNS-3	2016	0	0	0	0.0	0.0
	Platform: island	ANP-1	2017	3	2	2	66.7	100.0
		ANP-2	2018	2	2	1	100.0	50.0
		ANP-3	2018	3	2	2	66.7	100.0
		ANP-4	2019	3	3	2	100.0	66.7
		ANP-5	2019	2	2	2	100.0	100.0

the end of 2016 to provide more nesting sites to the birds on the island after unsuccessful breeding on natural nesting sites.

The stages of breeding such as incubation, hatching, and fledging success was recorded. The activity was observed through binoculars or a spotting scope. The observations were taken from a vantage point ranging from 50 to 150 metres depending upon the site characteristics and the response of the birds to the observer (Clancy, 2006). Information such as disturbance due to developmental activities and interspecies competition were also recorded. The nests were monitored daily, early morning and late evening for 30 minutes.

The hatching success was calculated by taking the percentage of hatchlings out of clutch size, and the fledging success was calculated by taking the percentage of fledgelings out of the total number of hatchlings. The data were analysed using the non parametric Man-Whitney U Test in Statistica 10 statistical software for data between locations, nest types, and years.

Nest construction starts earliest in early December. Out of 17 nests studied, the birds used the same nest 14 times. The same nests were used nine times at the two locations in Al Sila forest, and five times at the two platforms at Sir Bani Yas Island.

In 2014, only one breeding pair of Ospreys was recorded on Sir Bani Yas Island. They constructed a nest on a sand berm at the edge of the beach and laid three eggs. Only two eggs hatched with a hatching success of 66.7%. Both young died on the fourth day due to a robust cold gale, eventually leading to zero fledging success. In 2015 and 2016, the birds constructed nests but did not lay any eggs. In 2015, they constructed a nest on a telecommunication tower but abandoned it without laying eggs. Later, Egyptian Geese (*Alopochen aegyptiaca*) took over the nest.

The average clutch size in the natural nesting sites was 2.33±1.15 eggs per nest, while it was 2.60±0.55 for nests on platforms. The difference is statistically not significant (U=30.0; P=1.0) (Table 1). The mean incubation period was 35.0±2.16 days for all nests. The mean number of hatchlings was 1.92±1.08 in natural nesting sites and 2.20±0.45 hatchlings at nesting platforms. The difference was statistically not significant (U=28.0; P=0.87). The mean hatching success was 69.44±38.82 per cent in natural nests, and 86.67±18.26 per cent at nesting platforms. Neither were these differences was significant (U=24.0; P=0.56).

The mean fledging period of all nests was 53.0±4.58 days. The mean number of fledgelings in natural nests was 1.50±1.09 fledgelings compared to 1.80±0.45 fledgelings in the platform nests on the island (difference not significant; U=26.0; P=0.71). The mean fledging success was 65.28±42.91 per cent for natural nesting sites and 83.33±23.57 per cent for nesting platforms. The platform occupancy rate was 33% in 2017 and 67% in 2018 and 2019.

Multiple factors could have attributed to the failure of egg-laying, such as continuous disturbance from Egyptian Geese and the construction of a new cruise ship beach. Geese are reported to take over Osprey nests and artificial platforms in many areas (Henny, Collins, & Deibert, 1978). Moreover, in 2016, construction works were the cause of disturbance.

The present study shows that the provision of nesting platforms was successful in enhancing the reproduction rate of the Ospreys on the island. The nests on platforms were more successful in producing fledgelings compared to nests on natural substrates in disturbed habitats and with interspecific competition for nesting sites. The provision of platforms reduces competition for nesting sites and provides safety to adults and young.

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Disclosure Statement

No potential conflict of interest was reported by the authors.

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Appendix V: Curriculum Vitae

BILAL KABEER

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Professional Summary

Experienced Assistant conservation manager providing services with demonstrated history of working in the animal conservation services industry. Skilled in sustainability, Wildlife, Data analysis, Biodiversity and science. Strong programme and project management. Professional with a master of philosophy (M.Phil.) focused in Wildlife Management.
Ph.D. Aspirant at CULS university Czech Republic.

Professional Experience

(United Arab Emirates)

March 2015 –Current	Barari Natural Resources, UAE

Assistant Conservation Manager/Zoologist

- Contract Management:
- Planning, strategies, and protocols provided by management their implementation in the field and execution as per SOPs.
- Managing and coordinating the field operations of a globally important collection of desert fauna on Sir Bani Yas Island. Monitor the status and trends of wildlife populations.
- Manage endangered species populations, including conservation, protection, and rehabilitation
- Promoting Ecotourism and give innovative plans for improving the tourists, experience along with the supreme objective of animal welfare and wildlife conservation
- Record keeping, preparation of guidelines, protocols and working schedules for client
- Managing feeding of 16,000 animals at the island on a daily basis pellet feeding and grass, visit sites and manage clearance and good hygienic conditions for animals
- Facilitate field staff in segregating & sorting data as directed by the reporting structure staff
- To facilitate in reporting structure in different development activities for proper data storage, registers, stock list and keeping updated as needed
- To update by any new innovation for management of data on day to day wildlife management

Professional Skills

- Operations Management
- Team and Resource Management
- Strategy and Policy Development
- Budget Management
- Procurement
- Asset Management
- Project Proposals
- Report and Presentation
- Internal & External collaboration
- Wildlife Management
- Forest / Botany Management

Soft Skills

- Negotiation and public dealing
- Proficient in English
- UAE Driving license
- Expert in Animal Welfare
- Proficient in MS Project

Personal Information

Date of Birth: 15-03-1988
Gender: Male
Marital Status: Married
Nationality: Pakistani
Residence Address: Abu Dhabi

Operations Managing:

- Animal Husbandry
- Animal Monitoring
- Carnivore Monitoring
- Bio-security
- Feeding and Watering
- Manpower Management
- Monitoring interspecies interaction
- Census
- Camp Management
- Animal Health
- Vehicles and logistics
- Physical capture of animals

Wildlife Services' Management

- Collaborate with other institutions for breeding loans and animal donations, research and trainings
- Promote eco-tourism on the island and improve visitors' experience
- Maintain healthy animal collection and ensuring all basic requirements of the animals are met
- Designing animal vaccination and herd management plans with the wildlife manager
- Identifying opportunities to reduce animal feed cost through plantation for fresh fodder and browse for the animals
- Management of wildlife biosecurity

Dec 2013 – March 2015 | **Barari Natural Resources, Abu Dhabi**

AVIFAUNA BIOLOGIST

- Monitor and recording of birds on a monthly basis.
- Migratory birds surveys.
- Management of the Aviary and Birds.
- Rearing of Ratite chicks. (Ostrich, Emu & Rhea).
- Record keeping of bird's

Nov 2010 – Nov 2013 | **PARC, Pakistan**

RESEARCH ASSISTANT

- Study on Biology Captive Breeding of Endangered Wild Animals In captivity at Poultry& Wildlife Research Section"
- "Genetic Improvement of Selected Indigenous Poultry Breeds"
- Worked on two research projects
- Aviary management, monitoring birds, supervision of staff
- Data Recording
- Developing Technical and financial reports
- Work with poultry management include backyard poultry rearing

Aug 2010 – Oct 2010 | **Biodiversity Park, Attock Oil Refinery, Pakistan**

RESEARCH INTERNEE

- Management of Biodiversity Park.
- Monitor and record behavior of bird's species in Aviary.
- Maintenance of Botanical garden
- Management of staff and daily operations

EDUCATION

2015 – In Progress | **Czech University of Life Sciences, Prague, Czech Republic**

- **Degree: Ph.D. 2015- in Progress(Animal Science and Food Processing)**
- **Research**: Bird communities at an offshore island of Abu Dhabi, Sir Bani Yas, UAE.
- **Courses**: Ecology, Animal Production, Ornithology, Biochemistry, Zoo-hygiene a presence, Livestock production in tropics and subtropics, Management of research and Dissertation Methodology.

2013-Completed | **Pir Mehr Ali Shah, Arid Agriculture University, Pakistan**

- **Degree: M. Phil. (Master of Philosophy in Wildlife Management) 2013.**
- **Research**: Feed preference of Hog deer (*Axis porcinus*) under captivity
- **Courses:** Forest recreation and park management, Bio-statistical analysis, Protected areas and management, Endangered species and their management, Essentials of wildlife conservation-National perspectives, Forestry and environment, Wildlife study techniques –Management aspects, Wildlife food and foraging, Management aspects of wildlife behavior, Wildlife policies legislation and international conventions and Bio-statistical Analysis.

2010-Completed | **Pir Mehr Ali Shah, Arid Agriculture University, Pakistan**

- **Degree: M.Sc. (Master of Science in Wildlife Management) 2010.**
- **Research**: Status of water birds at Kallar Kahar Lake Chakwal, Pakistan.
- **Courses:** Principal of wildlife management, Wildlife study techniques, Mammalogy, Elements of statistics and biometry, Ornithology, Conservation Biology, Experimental statistics, Terrestrial wildlife management, Wildlife wetland management, Wildlife population ecology, Wildlife damage management, and Herpetology

2007-Completed | **Punjab University, Pakistan**

- **Degree: B.Sc. (Biological Sciences) 2007**
- **Institute:** Punjab University, Pakistan
- **Courses:** Zoology, Botany, and Chemistry

Training Objectives/Certifications

2017 | **Insect Taxonomy & Field Sampling Skills**

- Insect Taxonomy & Field Sampling Skills from Oxford university

2015 | **Field Survey Tecniques**

- Field survey techniques to study birds from Oxford university

2012 | **Scientific Technological Workshop OIC**

- High altitude ecosystem and Climate change from Comstech Institute, Islamabad.

2010 | **Animal Husbandry**

- Physical capture & restrain from Pakistan Agriculture Research Council

Publications

1. Abid Mehmood, Sadia Abid, Pavla Hejcmanová, Muhammad Arslan Asadi, **Bilal Kabeer**, Muhammad Jawad Jilani, Sadaf Bilal, Muhammad Waseem Ashraf. 2019. Comparison of physiological responses of Arabian striped hyaena (*Hyaena hyaena sultana*) to effective immobilisations with ketamine-medetomidine and ketamine-xylazine in (semi-) captive conditions. Peer J 7:e7326.

2. **Bilal Kabeer**, Maqsood Anwar, Muhammad Rais, Muhammad Jawad Jilani, Muhammad Arslan Asadi, Sadia Abid, Sadaf Bilal, Farrukh Saleem, Babar Hilal Ahmed, Agha Waqar Yunus, Saleem Zahid, Muzamil Anjum, Pavla Hejcmanova, Muhammad Kamal Sheikh and Abid Mehmood.2018. Study of Feed Preference of endangered Hog deer (*Axis Porcinus*) under captive conditions in Pakistan. Journal of International Journal of Conservation Science. Volume 9, Issue 2, April-June 2018:337-344.

3. Farrukh Saleem, Babar Hilal Ahmad, Saleem Zahid, and **Bilal Kabeer**. 2014. Comparative productive performance of indigenous naked neck and naked neck crossbred layer chickens. Journal of Agriculture Research. Res. Vol. 27 No.4, 2014.

4. Sadia Bilal, Muhammad Rais, Maqsood Anwar, Iftikhar Hussain, Madiha Sharif, **Bilal Kabeer**.2011.Habitat association of Little Grebe (*Tachybaptus ruficollis*) at Kallar Kahar Lake, Pakistan. Journal of King Saud University – Science. Volume 25, Issue 3, July 2013, Pages 267-270.

5. Noman Khalique, Muhammad Rais, Tariq Mehmood, Maqsood Anwar, Sakhawat Ali, Sadia Bilal, **Bilal Kabeer**. 2012. Study on Some Waterfowls of Mangla Dam, Azad Jammu, and Kashmir. Journal of population and fauna, Ukraine.Vol.21 No.44-49, 2012.

6. M. Rais, **B. Kabeer,** M. Anwar and T. Mehmood.2010. Effect of habitat degradation on breeding water birds at Kallar Kahar Lake District Chakwal. The Journal of Animal and Plant Sciences. 20(4), 2010, Page: 318-320.

7. **Bilal Kabeer**, Sadaf Bilal, Sadia Abid, Pavla Hejcmanová, Muhammad Arslan Asadi, Muhammad Jawad Jilani &Abid Mehmood.2020. Breeding of the Osprey, (*Pandion haliaetus*), in natural and artificial nesting substrates in the United Arab Emirates (Aves: Accipitriformes). Zoology in the Middle East. Volume 66, 2020 - Issue 2.

8. **Kabeer B**, Bilal S, Abid S, Hejcmanová P, Mehmood A, Asadi MA and Jilani MJ. Some aspects of breeding ecology and threats to Saunders's tern (*Sternula saundersi*) at an offshore island of United Arab Emirates. Water Birds. (Accepted).

9. **Kabeer B**, Bilal S, Abid S, Hejcmanová P, Asadi MA, Jilani MJ and Mehmood A. 2021.Determining population trend and breeding biology of Common Kestrel(*Falco tinnunculus*) at Sir Bani Yas Island of Emirates. Journal of Animal and Plant Sciences.Volume 31(2):2021:596-603.

Conferences, Exhibitions, and Seminar

- Participated in 1 day ACTIVE SUPPORT IN THE FOD WALK CAMPAIGN in Sir Bani Yas Airport by Abu Dhabi Airports. (2015).
- Letter of Appreciation to be Part of CONSERVATION INTRODUCTION OF ARABIAN TAHR ON SIR BANI YAS ISLAND by The Arabian Tahr steering Committee (2014).
- Certificate of participation on the occasion of Spring Festival FANCY BIRD & DOG SHOW (2013).
- Certificate of Appreciation by Pakistan wildlife foundation for contribution as YOUNG SCIENTIST to nature conservation in Pakistan. (2013).
- Certificate of Merit Laptop (Awarded with Laptop) on the basis of merit to excel professionally YOUTH INITIATIVE, GOVERNMENT OF PUNJAB. (2012).
- Participated in 3 days INTERNATIONAL ZOOLOGICAL CONGRES in GC University Lahore Pakistan (2012).
- Participated in 3 days INTERNATIONAL ZOOLOGICAL CONGRES in University of Azad Jammu & Kashmir, Muzaffarabad, Pakistan (2011).
- Certificate for 1-day participation in Energy Conservation Training Workshop/Seminar on Agriculture, Buildings, Transport, Industry & Power and Clean Development Mechanism, PC Hotel, Pakistan.

Computer Skills

- M.S Word
- M.S PowerPoint
- M.S Excel, M.S Access
- M.S FrontPage
- Adobe Photoshop
- In-Page (Urdu)
- E-mail/Internet

Reference

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- Dr. S M H Andarabi, Principal Scientific Officer Pakistan Agriculture Research Centre, Islamabad, (andrabi123@yahoo.com)+92335167360).