PODOCES
2011
Vol. 6, No. 1
Journal homepage: www.wesca.net

Breeding Waterbird Populations of the Islands of the Northern Persian Gulf, Iran

Farhad Hosseini Tayefeh[1,2], Mohamed Zakaria[2], Hamid Amini[3], Saber Ghasemi[4] & Meysam Ghasemi[5]

1) Bushehr Provincial Office of the Department of the Environment (DOE), Bushehr, Iran
2) Faculty of Forestry, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor Darul Ehsan, Malaysia
3) Department of Environment and Energy, Science and Research Branch, Islamic Azad University, Tehran, Iran
4) Islamic Azad University, Bandar Abbas Branch, Bandar Abbas, Iran
5) Hormozgan Provincial Office of the Department of the Environment (DOE), Bandar Abbas, Iran

Article Info
Original Research

Received 12 May 2011
Accepted 8 September 2011

Keywords:
Breeding population
Conservation
Island birds
Iran
Persian Gulf
Waterbirds

Abstract
In 2010, we estimated the breeding waterbird populations on the uninhabited islands of the northern Persian Gulf, some of the most important waterbird nesting sites in Southwest Asia. We also compared the 2010 census results with data from the 1970s. Over 120,000 breeding pairs of waterbirds of nine species were estimated on seven islands in 2010. The most abundant species were Bridled Tern *Sterna anaethetus* (74,113 pairs) and Lesser Crested Tern *Sterna bengalensis* (30,799 pairs). The results indicated that 20% of the global population of Crab Plover *Dromas ardeola* breed in the northern part of the Persian Gulf. The breeding population of White Cheeked Terns *Sterna repressa* had decreased by about 98% since the 1970s, while the populations of all the other species had increased. Further monitoring of the breeding waterbirds is needed in order to suggest appropriate measures for the conservation of these important waterbird populations. Compared with the situation in the 1970s, some islands are no longer suitable as nesting sites for waterbirds because of human exploitation, occupation by the military and development for the oil and gas industries.

1. Introduction

Due to their need for access to food resources and for avoidance of predators and human disturbance, colonies of ground-nesting waterbirds are often located on small and remote offshore islands (Lack 1968, Cody 1985, Ratcliffe et al. 1999, Gibbons & Gregory 2006). The Persian Gulf, with an area of 251,000 km^2, is an extension of the Indian Ocean located in Southwest Asia between Iran and the Arabian Peninsula. The environment of the Persian Gulf is very rich in natural phenomena such as mangroves, fishing grounds and extensive coral reefs, and possesses many inhabited and uninhabited offshore islands that support hundreds of thousands of wintering birds and are key habitats for ground-nesting waterbirds (Fatemi & Shokri 2001, Scott 2007).

The uninhabited islands of the northern Persian Gulf support large nesting colonies of waterbirds (Scott 2007) and have been designated as Important Bird Areas (IBAs) in the Middle East (Evans 1994, Scott 1989, 2007). Biogeographically, the Persian Gulf lies in the Western Palearctic region, although much of the bird fauna of the Persian Gulf coast has

* *Corresponding: farhadtayefeh@gmail.com*

affinities with the Oriental region (Cramp et al. 1983, Scott 1989, Newton 2007). Several typically Oriental species reach the northwestern extremity of their ranges in the south of Iran. At least nine waterbird species of the Indian Ocean breed on the islands of the Persian Gulf (Scott 1989).

Few breeding bird surveys have been carried out at islands in the Persian Gulf. Roselaar & Aliabadian (2007, 2009) reviewed the literature on breeding birds in Iran during the period 1876 to 1977 and reported on rare birds in Iran between the 1860s and 1960s. Their work revealed that among 250 titles of books and articles about the birds of Iran, only a few references deal with birds of the Persian Gulf islands (Sharpe 1886, Cheesman 1922, Baker 1923, Ticehurst et al. 1925, Løppenthin 1951, Tuck 1974, Chilman 1982, Gallagher et al. 1984). The first survey of breeding seabirds in the Persian Gulf was carried out by Ticehurst et al. (1925), and several islands were surveyed by personnel of the Department of the Environment in the 1970s (Scott 2007). Gallagher et al. (1984) reported on the status of seabirds breeding on some islands of the Persian Gulf, including Iran, and Evans (1994) identified some of the islands as Important Bird Areas in the Middle East. However, these two last reports were based on fieldwork carried out prior to 1977.

In the last 30 years, only a little information has been published on the breeding seabirds of the northern Persian Gulf. Studies during this period have included breeding bird censuses on Sheedvar Island (a Ramsar Site) in 1981, 1982, 1990, 1997 and 2005 (Mansoori 1987, Ornithology Unit of Iran DOE, DOE Provincial Office of Hormozgan, unpubl. data), breeding bird censuses on islands in Mond Protected Area in the years 2002–2005 (DOE Provincial Office of Bushehr, unpubl. data), and nest counts of four tern species and Western Reef Heron on Nakhilu Island from 2005 to 2007 (Behrouzi-Rad & Tayfeh 2008).

The aim of the present study was to determine breeding species diversity and population sizes of waterbirds on the islands in the Persian Gulf. Most of the islands potentially suitable for breeding waterbirds were surveyed during the 2010 breeding season. Some of the islands were found not to be suitable for breeding waterbirds as they were inhabited, while some of the islands (Farsi, Booneh, Kharku, Greater Tunb and Lesser Tunb) were inaccessible for security reasons. Only seven of the islands visited were found to be supporting breeding waterbirds. The size of the waterbird populations on each of the islands and trends in these populations can be used as indicators for assessment of the health of the environment in the Persian Gulf, where oil production is such an important activity.

The objectives of this paper are to provide complete census data on breeding waterbird populations on islands in the northern Persian Gulf in 2010, to draw attention to several hitherto unknown breeding populations of Crab Plover *Dromas ardeola*, and to compare the present waterbird population sizes with previous estimates to indicate overall trends in the breeding population for each species after four decades.

2. Materials and Methods

Waterbirds were surveyed on seven of the 25 Iranian islands in the northern part of the Persian Gulf: Sheedvar, Bani Farour, Omol-Karam, Nakhilu, Khan, Ghabr-e Nakhoda and Dara (Fig. 1). The surveys were conducted between late March and the end of August 2010, with a minimum amount of time being spent at each colony to avoid desertion by breeding pairs or overheating of the eggs, as recommended by Bibby et al. (2000) and Steinkamp et al. (2003). The coordinates of the nesting colonies were taken with a GPS, and the total surface area of each colony was measured. The number of breeding pairs was estimated on the basis of Apparently Occupied Nest-sites (AONs), i.e. nests with eggs or apparently active nests prior to egg-laying (Bibby et al. 2000, Gibbons & Gregory 2006, McGowan et al. 2008, Seavy & Reynolds 2009). Each AON was considered to indicate a pair of breeding birds.

To measure the number of AONs of any species in a colony, the colony was assigned to one of three categories according to size: 1–200 AONs, 201–500 AONs and over 500 AONs. A total count of all AONs was made for each species in small colonies comprising fewer than 200 AONs. For all species in colonies with 200–500 AONs, as well as for Crab Plovers and Bridled Terns *Sterna anaethetus* on Omol-

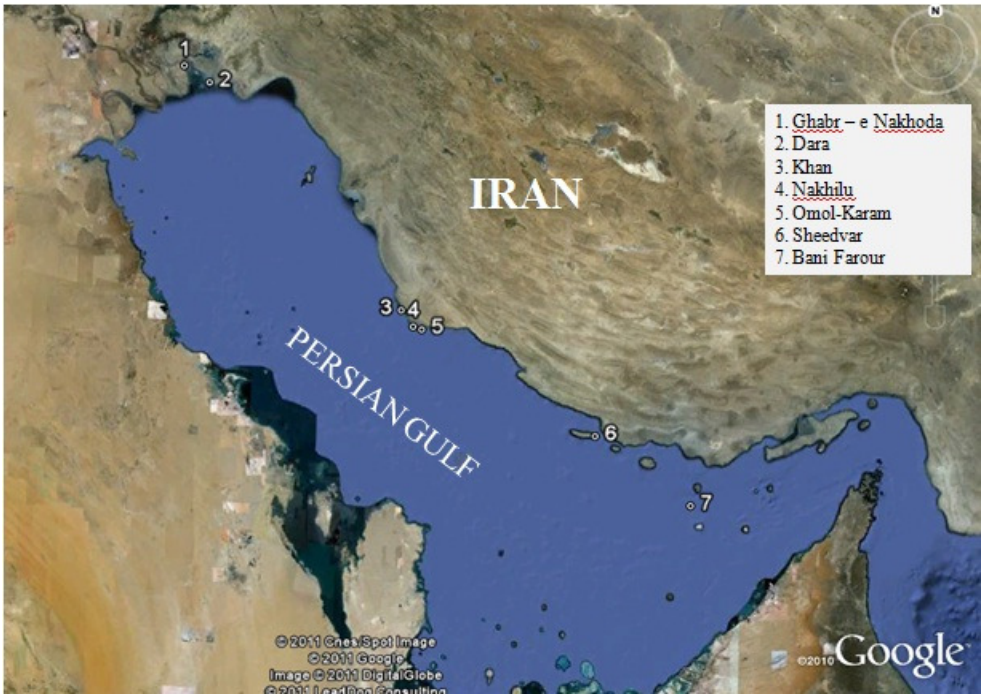

Fig. 1. Location of breeding sites of waterbirds in the northern Persian Gulf (from http://maps.google.com).

Karam, Dara and Ghabr-e Nakhoda islands, the colonies were divided into smaller units so that a total count could be made of the AONs in each unit separately, a method described by Bibby et al. (2000), Gibbons & Gregory (2006), Schwarz (2009) and Steinkamp et al. (2003). The tracks of Crab Plovers at a burrow entrance were used to identify active nests of this species (De Marchi et al. 2006).

A Stratified Random Sampling method was applied to obtain an estimate of the population size for large colonies comprising more than 500 nests of Lesser Crested Tern *Sterna bengalensis* and Swift Tern *Sterna bergii* (Walsh et al. 1995, Krebs 1999, Bibby et al. 2000, Gregory et al. 2004, Greenwood & Robinson 2006, Steinkamp et al. 2003, Newton 2006). The large colonies were divided into three strata: Lesser Crested Terns only, Swift Terns only, and Lesser Crested Tern and Swift Tern mixed. The area of each of these strata was measured separately. To get an estimation of the number of AONs in large colonies, quadrates of 1×1m were located randomly within each stratum so that the total area of the quadrates covered at least 5% of each stratum (Steinkamp et al. 2003, Greenwood & Robinson 2006). The mean number of AONs per m^2 was then calculated for each stratum and multiplied by the total area of the stratum to obtain an overall estimate of active nests. To minimize the amount of time spent by the observers in the colony, each visit was restricted to a maximum of 15 minutes duration. All visits were undertaken in the early morning (06:00–09:00) and late evening (18:00–20:00). Most colonies of nesting terns are very difficult to count with an acceptable degree of precision because of re-nesting attempts and shifting to another colony by unsuccessful pairs (Steinkamp et al. 2003). To avoid overestimating the number of nests, the highest Mean Incubation Counts during the nesting season (MIC_{max}) were used at each colony (Seavy & Reynolds 2009), i.e. the nest count for Bridled Terns was conducted during late incubation and early chick period when almost one fourth of the eggs had hatched.

To estimate the number of breeding pairs of Bridled Terns whose nests were hidden under bushes and difficult to locate, a systematic sampling method was used (Walsh et al. 1995, Young & Young 1998, Bibby et al. 2000, Krebs 2000, Steinkamp et al. 2003, Gregory et al. 2004, Greenwood & Robinson 2006, Morrison et al. 2008, Schwarz 2009). This involved the

selection of sampling quadrates in a regular pattern on Sheedvar, Bani Farour and Nakhilu islands. In order to develop these estimations, the area with over 5% vegetation cover occupied by the colony was determined. Quadrates were placed at equal distance along linear transects crossing the whole breeding colony so that transects were parallel and 100 m apart. The distance between each quadrate was 50 m on Nakhilu Island and 150 m on Sheedvar and Bani Farour islands because of the higher density of the vegetation. The size of the quadrates was 20×20m on Nakhilu and 10×10m on Bani Farour and Sheedvar islands.

The location of the transects was chosen following a grid map while in the field, with the starting point of each transect located by map reading, and with the location of the first quadrate chosen randomly (Barbraud & Delord 2006). The surface area of the colonies was measured using a GPS, and direction was established using a GPS compass. The mean number of AONs was calculated per quadrate and then per ha, and then multiplied by the total area of the colony in order to estimate the total number of nests. One-way Analysis of Variance (ANOVA) and Tukey post-hoc tests were used to compare mean values of nests/ha between Bridled Tern colonies using SPSS 16 software.

3. Results

3.1. Bridled Tern

Bridled Terns bred on six of the seven remote islands in the northern Persian Gulf surveyed during the 2010 breeding season (Table 1). On Nakhilu, Bani Farour and Sheedvar, the total numbers of nests were estimated at 16,924 ± 1,204, 29,432 ± 1,345 and 26,488 ± 2,666 respectively. The results of an ANOVA analysis revealed that there were highly significant differences between the mean value of nests/ha on these three islands ($F_{2,124} = 21.28$, $P<0.01$). The maximum mean value of nests/ha was observed at Nakhilu Island (735 ± 54), while the minimum was observed on Sheedvar Island (308 ± 31). In addition, 800, 120 and 350 Bridled Tern nests were counted on Ghabr-e Nakhoda, Omol-Karam and Dara islands respectively. Thus, the total number of AONs of Bridled Terns on the islands of the northern Persian Gulf was calculated at 74,113 ± 5,066.

3.2. Lesser Crested Tern and Swift Tern

Breeding colonies of these birds were found at six islands during the 2010 breeding season (Table 2). On 14 June, the total number of Lesser Crested Tern nests on Nakhilu Island was estimated at 4,585 ± 262, while the mean number of nests/m^2 was calculated at 7.32 ± 0.41. Moreover, a total of 140 Swift Tern nests were counted within this colony. A small colony with 450 Lesser Crested Tern nests and 32 Swift Tern nests was found on 29 June not far from the main colony. On Omol-Karam Island, Lesser Crested Terns and Swift Terns laid their eggs in two large colonies and a smaller one. At the first large colony, the mean value of nests/m^2 was calculated at 12.24 ± 0.18 in the Lesser Crested Tern breeding area while it was 7.43 ± 0.22 in the Swift Tern breeding area. Within the mixed breeding area, the mean numbers of Lesser Crested Tern and Swift Tern nests were 5.89 ± 0.43 and 3.36 ± 0.32 respectively. At the second large colony (with an area of 361m^2), the total of Lesser Crested Tern nests was estimated at 4,779 ± 86. Furthermore, 125 Swift Tern nests were counted at the edge of this colony.

The earliest breeding colony of these species was observed on 29 April when 872 Lesser Crested Tern nests and 144 Swift Tern nests were counted in two colonies on Khan Island. However, these colonies were destroyed by a high tidal flood and the birds disappeared. On 20 May, a new colony of Lesser Crested Terns was found covering an estimated 255 m^2 and with 12.71 ± 0.26 nests/m^2. Most parts of this colony were also flooded by a high tide on 2 June. The rest of the colony expanded again to 115 m^2 in area, but was also ruined by High Spring Tidal Water (HSTW) at 08:30 on 15 June. The total number of nests (MIC_{max}) of Lesser Crested Terns on Khan Island was estimated at 3,241 ± 66. The total number of Swift Tern nests was 144.

Totals of 450 Lesser Crested Tern nests and 25 Swift Tern nests were counted on Sheedvar Island, but all of the eggs were collected by local people. Both species also nested on Ghabr-e Nakhoda Island, where there were 666 Lesser Crested Tern nests and five Swift Tern nests. In total, it was estimated that there were 30,799 Lesser Crested Tern nests and 4,614 Swift Tern nests on the islands of the northern Persian Gulf during the 2010 breeding season.

Table 1. Estimated number of breeding pairs of Bridled Tern *Sterna anaethetus* on islands of the northern Persian Gulf in 2010.

Survey date	Island name	No. of quadrates	Mean no. of nest /quadrate	Nesting area (ha)	Mean no. of nests/ha	Total no. estimated nests
14 June	Nakhilu	59	29.41± 2.15 (20×20m)	22.4	735.25 ± 53.75 (+ 455 outlier nests)	16,924 ± 1,204
13 June	Omol-Karam					120
20 June	Bani Farour	32	5.91 ± 0.27 (10×10m)	49.8	591 ± 27	29,431 ± 1,344
18 June	Sheedvar	36	3.08 ± 0.31 (10×10m)	86	308 ± 31	26,488 ± 2,666
16 May	Ghabr-e Nakhoda					800
16 May	Dara					350
TOTAL						**74,113± 5,066**

Table 2. Estimated number of Lesser Crested Tern *Sterna bengalensis* (LCTE) and Swift Tern *Sterna bergii* (SWTE) nests on islands of the northern Persian Gulf in 2010.

Date	Island name	Location	Nesting area m^2 (no. of quadrate)			Mean value of nest /quadrates				Total	
						LCTE	SWTE	Mix		LCTE	SWTE
			LCTE	SWTE	Mix			LCTE	SWTE		
2 June	Omol-Karam (colony 1)	N27°50'01" E051°33'36"	525 (45)	189 (23)	239 (28)	12.24 ± 0.18	7.43 ± 0.22	5.89 ± 0.43	3.36 ± 0.32	7,833	2,207
30 June	Omol-Karam (colony 2)	N27°49'59" E051°33'28"	361 (34)			13.24 ± 0.24				4,780 ± 86.6	125
14 June	Nakhilu (colony 1)	N27°49'19" E051°28'10"	640 (57)			7. 32 ± 0.41				4,685 ± 262.4	140
29 June	Nakhilu (colony 2)	N27°49'18" E051°28'08"								450	32
29 April	Khan (colony 1)	N27°59'50" E051°19'45"	192							872	144
20 May	Khan (colony 2)	N27°59'47" E051°19'55"	255			12.71 ± 0.26				3,241 ± 66.3	0
15 May	Ghabr-e Nakhoda	N30°18'21" E048°54'37"	84			7.94 ± 0.42				667 ±35.3	5
19 June	Sheedvar	N26°07'20" E054°26'17"								450	25
20 June	Bani Farour	N26°47'22" E053°24'30"			1,100 (37)			7.11± 0.60	1.76 ± 0.43	7,821 ± 660	1,936 ± 473
TOTAL										**30,799**	**4,614**

Table 3. Estimated number of breeding pairs of Crab Plover *Dromas ardeola* on islands of the northern Persian Gulf in 2010.

Island name	Survey date	Colony location	Nesting area (m^2)	No of nests	Nest density/100m^2
Nakhilu	14 June	N27°49'24" E051°28'21"	7,827	1,102	14.08
Omol-Karam	15 June	N27°50'03" E051°33'38"	6,750	1,221	18.09
Ghabr-e Nakhoda	16 May	N30°18'22" E048°54'40"	21,900	2,155	9.84
Dara	16 May	N30°05'56" E049°06'00"	19,628	3,527	17.97
TOTAL			**56,105**	**8,005**	

Table 4. Numbers of breeding pairs of other waterbirds on islands of the northern Persian Gulf in 2010.

Species	Islands					Total
	Ghabr-e Nakhoda	Omol-Karam	Nakhilu	Khan	Sheedvar	
Gull-billed Tern				69		69
White-cheeked Tern		36	36		2,125	2,197
Caspian Tern				76		76
Western Reef Heron	6	24	42	92	45	209
Kentish Plover	2	5	8			15

3.3. Crab Plover

Nesting sites of the Crab Plover were discovered on four islands in the Persian Gulf in 2010 (Table 3). A total of 1,102 nests with the average of 14.08 nests/100m^2 were recorded on Nakhilu Island. A total of 1,221 nests with an average of 18.09 nests/100m^2 were counted on Omol-Karam Island. Furthermore, 2,155 nests with an average of 9.84 nests/100m^2 and 3,527 nests with an average of 17.97 nests/100m^2 were estimated on Ghabr-e Nakhoda and Dara islands respectively. In total, 8,005 nests were recorded on the islands of the northern Persian Gulf during 2010. The total area covered by the breeding colonies was 56,105 m^2; with the large colonies on Ghabr-e Nakhoda and Dara islands covering 21,900 and 19,628 m^2 respectively.

At three of the Crab Plover colonies, some cases of re-nesting were observed near the main colony. A new colony with 145 burrows was established 50m away from the main colony on Nakhilu Island. Of the 50 burrows examined using a burrow scope, 12 burrows contained one egg, 25 burrows contained chicks between 3 and 5 weeks old and the rest (26%) were empty. At least 40 new active burrows were counted next to the main colony on Omol-Karam Island on 15 July. On 17 July, a new colony was discovered with 3,550 burrows, 200m away from the first colony on Dara Island. Of 50 burrows that were checked randomly using a burrow scope, just two burrows contained eggs, 12 burrows contained chicks between 2 and 5 weeks old and the others were empty. Some chicks were frightened away when we approached close to the colony. Only a few eggshells were deposited by parents outside their nests in the main colony.

3.4. Other waterbirds species

Five other species of waterbird were found breeding on the islands of the northern Persian Gulf in 2010: Western Reef Heron *Egretta gularis*, White-cheeked Tern *Sterna repressa*, Caspian Tern *Sterna caspia*, Gull-billed Tern *Gelochelidon nilotica* and Kentish Plover *Charadrius alexandrinus*. The most abundant of these was White-cheeked Tern with 2,197 nests; the least abundant was Kentish Plover with only 15 (Table 4).

4. Discussion

4.1. Status of breeding waterbirds

In 2010, of the nine breeding species of waterbirds counted on the islands of the northern Persian Gulf, only the breeding population of one species, the White-cheeked Tern, had noticeably decreased since the 1970s, while the rest had increased to varying extents (Table 5). The total population of White-cheeked Tern was estimated at 100,000–300,000 pairs in the 1970s, with most of these breeding on Sheedvar Island, while only 2,197 pairs were located in 2010. Sheedvar Island may no longer be suitable for breeding White-cheeked Terns, as not enough bare area is left on the island. In the 1970s, there were 1,500–2,500 pairs of White-cheeked Terns nesting on Kharku Island, but there have been no reports of breeding by this species in recent years, possibly because of collecting of eggs by local people and the abundance of House Crows *Corvus splendens*.

An estimated 25,000–27,000 pairs of Bridled Tern were found breeding on islands in the northern Persian Gulf in the 1970s. The estimated total of 69,000–79,000 pairs in 2010 was almost three times as many. However, a large part of this apparent increase can be attributed to the large colony on Bani Farour Island which was never visited in the 1970s. The breeding population of Bridled Terns on Bani Farour, estimated at over 29,000 pairs in 2010, comprises almost half of the total

population in Iran. On the other hand, the breeding populations of Bridled Terns on Sheedvar and Nakhilu islands have increased considerably since the 1970s (from 3,000–5,000 to 26,500 on Sheedvar Island and from 15,000 to 16,900 on Nakhilu Island).

Many of the offshore islands, including Bani Farour and Khan, were not surveyed during the breeding season in the 1970s. Thus the totals given for Lesser Crested Tern and Swift Tern by Scott (2007) were incomplete. We found populations of these species breeding on Bani Farour and Khan islands, and also found that the breeding populations on Nakhilu and Omol-Karam islands had increased.

The results of this study indicate that over 20% of the global population of the Crab Plover breeds on the islands in the northern Persian Gulf. Therefore, these islands can be considered as key breeding sites for the survival of this species.

There are many potential reasons for differences in the size of the breeding populations of waterbirds on the Persian Gulf islands between years such as human exploitation, food availability, predation and natural events (Bibby et al. 2000, Steinkamp et al. 2003, Seavy & Reynolds 2009), in addition to possible differences in survey and census methods (McGowan et al. 2008). It is difficult to compare the results of surveys in the 1970s with those of surveys in 2010 because of the different coverage in the 1970s and 2010, although some islands were surveyed in both years.

Table 5. Estimated number of AONs of nine waterbird species on islands of the northern Persian Gulf in the 1970s (from Scott, 2007) and 2010.

Species	1970s	2010
Lesser Crested Tern	Many 1,000s	30,799
Swift Tern	900–1,300	4,614
Bridled Tern	25,000–27,000	74,113
Caspian Tern	30–50	76
Gull-billed Tern	2	139
White-cheeked Tern	100,000–300,000	2,197
Western Reef Heron	150–200	209
Crab Plover	>2000	8,005
Kentish Plover	not recorded	15

4.2. Threats

In 2010, all the colonies of Lesser Crested Tern on Khan Island were flooded on 28 May and 15 June during periods of high spring tides. It is estimated that 20% of the Lesser Crested and Swift Terns nests located on the periphery of the colony on Omol-Karam Island were also flooded on 15 June 2010.

The colony of Crab Plovers on Ghabr-e Nakhoda Island was heavily predated by hunters and egg-collecting by local people, and no alternative sites were available for re-nesting. The main threat to the Lesser Crested Tern and Swift Tern colonies on Bani Farour Island was the huge number of terrestrial crabs. It was observed that thousands of crabs moved from the sea to the colonies and damaged eggs and chicks. Scott (2007) believed that the huge decline in the number of breeding pairs of White-cheeked Terns on Sheedvar Island in the 1970s (from 300,000 in 1972 to only 27,000–45,000 in 1977) was attributed to egg-collecting for local markets. Egg-collecting still poses a serious threat to breeding terns on Sheedvar Island, as during the field visits in 2010, local people were frequently observed collecting eggs from the nests of Lesser Crested Terns and White-cheeked Terns.

On the other hand, egg-collecting does not appear to pose a serious threat to the Bridled Tern. The nests of this species are not concentrated in one area but are widely distributed at rather low density under bushes over most parts of the island. On Sheedvar Island, the Saw Scale Viper *Echis curinatus* is abundant and this poisonous snake inhibits local people from looking for Bridled Tern eggs. The increases in the number of breeding pairs of Bridled Terns on Sheedvar Island from an estimated 3,000–5,000 pairs in the 1970s to 24,000–29,000 pairs in 2010 may be a result of a change in the density of the vegetation on the island. Some 5,500 pairs of Bridled Terns were found nesting on Tahmadon (Morghu) Island in 1975 (Scott 2007), but there have been no recent records of this species breeding on Tahmadon, presumably because of the presence of Golden Jackals *Canis aureus* on the island.

At many of the Crab Plover colonies investigated during the present study, exploitation by humans resulted in the abandonment of nests and re-nesting attempts at other sites. In early May 2010, a new colony of

Crab Plovers near to a nesting area of Hawksbill Turtles *Eretmochelys imbricata* on Omol-Karam Island was disturbed by visiting researchers, and the birds left the colony and established another colony nearby. In May 2010, over one hundred adult Crab Plovers were killed by local fishermen on Ghabr-e Nakhoda and Dara islands for food. Moreover, small-scale egg-collecting and excavation of nests during the early egg-laying period were observed on Nakhilu and Ghabr-e Nakhoda islands. It seemed that many of the Crab Plover nests on Ghabr-e Nakhoda and Dara islands failed because of the hunting, egg-collecting, nest excavation and excessive disturbance by visiting fishermen. Some of the birds re-nested in a new colony adjacent to the main colony on Dara Island.

The northern Persian Gulf islands have increasingly come under pressure from development associated with the petroleum industry, since the Persian Gulf together with its coastal zone is known to be the biggest resource of crude oil and associated industries in the world. In addition, human exploitation including fishing, egg-collecting, hunting and outdoor recreation are becoming increasingly popular. These activities may have an adverse effect on the vegetation cover, soil texture and colonial breeding systems (De Marchi et al. 2006), especially at the beginning of the breeding season and during the chick rearing period. In addition to human activities, natural events such as very high tides, predation, storms and climate change might also have an adverse effect on large colonies of breeding seabirds (Schwartz 2005, Viera et al. 2006).

4.3. Conservation

Many remote and formerly uninhabited islands of the northern Persian Gulf such as Larak, Farour, Greater Tunb, Lesser Tunb and Kharku that were surveyed during the 20th century (Ticehurst et al. 1925, Roselaar & Aliabadian 2007, Scott 2007) are now inhabited and support military bases, oil and gas installations and transportation infrastructure. As a consequence, these islands have become unsuitable for breeding colonies of ground-nesting waterbirds. The other islands may be faced with the same or similar problems if they are not conserved properly. For instance, Sheedvar Island is facing a potential threat from the proposed development of a harbour for trade and transportation, while Omol-Karam, Tahmadun and Khan islands may be greatly affected by the development of oil and gas infrastructure in the near future.

Of the eight study sites, Nakhilu, Omol-Karam, Tahmadun and Khan islands are located in Dayer-Nakhilu National Park, and Sheedvar Island has been designated as a Ramsar Site and Wildlife Refuge. Because of their legal status within Iran's network of protected areas, these five islands are subject to higher levels of monitoring, management and protection than the unprotected islands. Since Bani Farour, Dara and Ghabre Nakhoda islands regularly support huge numbers of breeding waterbirds, they meet the Ramsar Convention criteria and therefore deserve to be designated as Ramsar Sites. If this could be achieved, a higher level of management and better degree of protection would be expected for these three islands.

During the breeding season, it is necessary to prevent all kinds of disturbance on the islands, e.g. egg-collecting by local people and uncontrolled visits by other people to islands where Crab Plovers regularly breed. As an urgent measure, it would be helpful to prepare a series of guidelines for controlling human access to the islands and keeping people outside the Crab Plover colonies to avoid the destruction of burrows. The development of awareness programs for local people and fishermen would certainly benefit the breeding birds on the Persian Gulf islands.

Acknowledgements

Logistical and financial support for this work was contributed by the Provincial Offices of the Department of the Environment (DOE) in Khuzestan, Bushehr and Hormozgan, Iran. Many thanks to Mr. Hossein Delshab for providing research facilities. For assistance in the field, we thank Gholamreza Faghih, Aghayar Moradi, Ardeshir Amini, Sadegh Poursalem, Khosro Darvishi, Hossein Jafari, Sirous Karami, Mehran Faghih and Mostafa Foladi.

References

Baker E.C.S. 1923. Remarks on eggs from Mesopotamia and the Persian Gulf. *Bull. Brit. Orn. Club* **43**: 70–71.

Barbraud C. & Delord K. 2006. Population census of blue petrels Halobaena caerulea at Mayes Island, Iles Kerguelen. *Antarctic Science* **18(2)**: 199–204.

Behrouzi-Rad B. & Tayfeh F. 2008. Nest Counts for Western Reef Heron Egretta gularis and Four Sterna species (repressa, anaethetus, bergii, bengalensis) on Nakhilu Island in the Persian Gulf from 2005 to 2007. *Podoces* **3(1/2)**: 45–52.

Bibby C.J., Burgess N.D., Hill D.A. & Mustoe S. 2000. *Bird census techniques* (2nd Ed.). Academic Press, London.

Cheesman R.E. 1922. Zoological investigations in the Persian Gulf and Iraq. *Journal of the Bombay Natural History Society* **28**: 1108–1110.

Chilman P.W.G. 1982. Migrants in the Persian Gulf during spring 1979. *Sea Swallow* **31**: 25–29.

Cody M.L. 1985. An introduction to habitat selection in birds. *Habitat selection in birds*, 3–56.

Cramp S., Simmons K., Brooks D., Collar N., Dunn E., Gillmor R. *et al.* 1983. *Handbook of the birds of Europe, the Middle East and North Africa. The birds of the Western Palearctic: 3. Waders to Gulls*. Oxford University Press, Oxford, UK.

De Marchi G., Chiozzi G., Semere D., Galeotti P., Boncompagni E. & Fasola M. 2006. Nesting, overwintering, and conservation of the Crab Plover Dromas ardeola in central Eritrea. *Ibis* **148(4)**: 753–764.

Evans M. 1994. *Important Bird Areas in the Middle East*. BirdLife International.

Fatemi S.M.R. & Shokri M.R. 2001. *Iranian coral reefs status with particular reference to Kish Island, Persian Gulf*. International Coral Reef Initiative Indian Ocean Regional Workshop, Muzambique, Nov. 26–28.

Gallagher M., Scott D., Ormond R., Connor R. & Jennings M. 1984. The distribution and conservation of seabirds breeding on the coasts and islands of Iran and Arabia. *Status and Conservation of the World's Seabirds* 421–456.

Gibbons D.W. & Gregory R.D. 2006. Bird. In S. W. J. (Ed.), *Ecological census techniques: A handbook.* (Vol. 2nd Edition, pp. 308–350). Cambridge University Press, Cambridge, UK.

Greenwood J.J.D. & Robinson R.A. 2006. Principles of Sampling. ***In:*** Sutherland W.J. (Ed.), *Ecological Census Techniques: A Handbook.* (2nd Ed., pp. 432). Cambridge University Press, Cambridge, UK.

Gregory R.D., Gibbons D.W. & Donald P.F. 2004. Bird census and survey techniques. ***In:*** Sutherland W. J. & Green R. E. (Ed.), *Bird Ecology and Conservation: a handbook of techniques*. Oxford University Press, pp. 27–35.

Krebs C. 1999. *Ecological Methodology*: Benjamin-Cummings Pub Co.

Krebs C. 2000. *Programs for Ecological Methodology.* Menlo Park, Bennjamin/Cummings, 654 pp.

Lack D.L. 1968. *Ecological Adaptations for Breeding in Birds.* Methuen, London, UK.

Løppenthin B. 1951. Seabirds of the Persian Gulf. *Proceedings X International Ornithological Congress (Uppsala 1951)* **10**: 603–610.

McGowan A., Broderick A.C. & Godley B.J. 2008. Seabird populations of the Chagos Archipelago, Indian Ocean: an evaluation of IBA sites. *Oryx* **42(3)**: 424–429.

Morrison M., Strickland M. & Block W. 2008. Wildlife Study Design. Springer Verlag, pp. 65–67.

Newton I. 2007. *The Migration Ecology of Birds*. Academic Press/Elsevier.

Newton S. 2006. Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) Implementation of the Strategic Action Programme (SAP) for the Red Sea and Gulf of Aden Guide to Standard Survey Methods for Seabirds. PERSGA. Saudi Arabia, http://www.persga.org/Documents/Mangroves_ActionPlan.pdf.

Ratcliffe N., Hughes J. & Roberts F. 1999. The population status of sooty terns Sterna fuscata on Ascension Island. *Atlantic Seabirds* **1:** 159–168.

Roselaar C. & Aliabadian M. 2007. A century of breeding bird assessment by western travellers in Iran, 1876–1977. *Podoces* **2(2)**: 77–96.

Roselaar C. & Aliabadian M. 2009. Review of rare birds in Iran, 1860s–1960s. *Podoces* **4(1)**: 1–27.

Schwartz M.L. 2005. *Encyclopedia of coastal science*: Kluwer Academic Pub.

Schwarz C. 2009. Sampling, Regression, Experimental Design and Analysis for Environmental Scientists, Biologists, and Resource Managers. *Simon Fraser University*.

Scott D. 1989. Birds in Iran. From http://www.iranica.com/articles/birds-in-iran

Scott D. 2007. A review of the status of the breeding waterbirds in Iran in the 1970s. *Podoces* **2**: 1–21.

Seavy N.E. & Reynolds M.H. 2009. Seabird nest counts: a test of monitoring metrics using Red-tailed Tropicbirds. *Journal of Field Ornithology* **80(3)**: 297–302.

Sharpe R.B. 1886. On a collection of birds from Bushir in the Persian Gulf. *Ibis* **4**: 493–499.

Steinkamp M., Peterjohn B., Byrd V., Carter H. & Lowe R. 2003. Breeding season survey techniques for seabirds and colonial waterbirds throughout North America. Draft report for the monitoring program of the North American Colonial Waterbird Conservation Plan, From http://www.waterbirdconservation.org/pubs/psgmanual03.pdf

Ticehurst C., Cox P. & Cheesman R. 1925. Birds of the Persian Gulf islands. *J. Bombay Nat. Hist. Soc.* **30:** 725–733.

Tuck G.S. 1974. Seabirds of the Persian Gulf (The Gulf) and Gulf of Oman.-A Survey (1958–1973). *Sea Swallow* **23**: 7–21.

Viera V.M., Le Bohec C., Côté S.D. & Groscolas R. 2006. Massive breeding failures following a tsunami in a colonial seabird. *Polar Biology* **29(8)**: 713–716.

Walsh P., Halley D., Harris M., Del Nevo A., Sim I. & Tasker M. 1995. Seabird monitoring handbook for Britain and Ireland. *JNCC, RSBP, ITE, Seabird Group*.

Young L. & Young J. 1998. *Statistical ecology: a population perspective*: Kluwer Academic Pub.