REPRODUCTIVE BIOLOGY OF PYGMY CORMORANT *PHALACROCORAX PYGMEUS* IN SIAHKESHIM PROTECTED AREA, NORTHERN IRAN

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Received 5 August 2008, accepted 9 October 2008

SUMMARY

BARATI, A., JAVAN, S. & SEHHATISABET, M.E. 2008. Reproductive biology of Pygmy Cormorant *Phalacrocorax pygmeus* in Siahkeshim Protected Area, Northern Iran. *Marine Ornithology* 36: 163–166.

The breeding ecology of the Pygmy Cormorant *Phalacrocorax pygmeus* was studied in 2007 in the Siahkeshim Protected Area, Anzali Wetland Complex, northern Iran. Nests were monitored from the start of egg-laying until fledging, and parameters including laying date, clutch size, nest and egg size, and breeding output were recorded. Chick diet was studied using regurgitated fish. The mean clutch size was 4.1 ± 1.3, median brood size was four and the median number of fledglings was three; 87% of the eggs hatched and 88% of the chicks survived to three weeks. The overall breeding success was 77% or 3.2 ± 0.7 fledglings per nest. The main fish species fed to the chicks was the benthic-living *Carassius carassius.* Measures for conservation of this near-Threatened species are discussed.

Key words: Breeding biology, Pygmy Cormorant, *Phalacrocorax pygmeus,* Siahkeshim, Iran

INTRODUCTION

The Pygmy Cormorant *Phalacrocorax pygmeus* is the smallest of the five species belonging to the Phalacrocoracidae occurring in the Middle East (Porter *et al.* 1996). Its geographic distribution is restricted to southeastern regions of western Palearctic, although in former years, it was more widespread; declines were registered in a few countries between 1990–2000 (Cramp & Simmons 1977). The breeding range of the species extends from coastal wetlands of northeast Italy, where the species has regularly bred in increasing numbers since the early 1990s (Volponi & Emiliani 1997), through Albania and Yugoslavia, east to Central Asia, north to the northern coasts of the Black, Caspian and Aral Seas, and south to the marshes of southern Iraq. Globally, the Pygmy Cormorant is listed as a species of Least Concern, because key populations in Azerbaijan and Romania are stable or increasing, and the overall population has increased slightly (BirdLife International 2008). It is listed in Appendix II of the Bern Convention, Annex I of the European Union Wild Birds Directive, Appendix II of the Bonn Convention and the African–Eurasian Migratory Waterbirds Agreement developed under the Bonn Convention (Crivelli *et al.* 1996). Wetland International has recognised two subpopulations of Pygmy Cormorant, a population breeding in Eastern Europe and Turkey, centred on the Black Sea, and a population breeding in western Asia, centred on the Caspian Sea. Currently, the global population is estimated at about 85 000–180 000 individuals (Delany & Scott 2006).

The breeding biology of this species is not well known, and few data are available on its breeding biology (Cramp & Simmons 1977). Information on the ecology and distribution of the Pygmy Cormorant is scanty and out-dated for most of its geographic range, and on the whole, insufficient to enable proper decisions on conservation actions to be made (Crivelli *et al.* 1996).

In Iran, the Pygmy Cormorant breeds in northern parts of the country (Scott 2007, Porter *et al.* 1996, Voskamp *et al.* 2005, Sehhatisabet 2006). In the present study, we focused on breeding biology in the Siahkeshim Protected Area, part of the Anzali Wetland in the southern Caspian Sea.

Study area

The Siahkeshim Protected Area, Giulan province, is situated in the Anzali Wetland Complex on the south coast of the Caspian Sea (37°22–27′N, 49°17–25′E) and covers an area of about 4500 ha. About 60% of recorded rainfall occurs in summer and autumn, 20%–30% in winter and 10%–20% in spring. The annual mean temperature is 16.1°C, and the annual mean precipitation is 1950 mm. This permanent freshwater wetland (Riazi 1997) is extremely important for wintering and breeding waterbirds. Most parts of the wetland are covered by *Phragmites australis.* The central portion of Siahkeshim (3515 ha) was first established as a protected region in 1967. The reserve was enlarged to 6701 ha and upgraded to a wildlife refuge in 1971, but it was reduced to its present size of 4500 ha and downgraded to protected area in the 1980s (Scott 1995). The Anzali Wetland Complex (15 000 ha) was designated as a Ramsar site in 1975. This site encompasses the whole of the Anzali Wetland, Siahkeshim, Selke, Espand and several other areas bordering the marshes. The wetlands have been identified as an Important Bird Area by BirdLife International (Evans 1994).

METHODS

Population status

The number of breeding pairs of Pygmy Cormorants in the Siahkeshim Protected Area in 2001, 2003 and 2007 was estimated by one or two observers counting all occupied nests in predefined areas.

Breeding biology

Forty randomly selected nests were monitored at irregular intervals (three, four, seven and 10 days) from early April in 2007. Nests were selected from various parts of the colony on the assumption that the selection of study nests would cover a representative sample of the colony. A motorboat was used to explore all parts of the colony looking for nests. Nests high in trees were accessed using a ladder. At each visit, we recorded the number of eggs or nestlings (both <20 days and >20 days post-hatch), nest size and location, number of nests in each tree, and egg measurements (length and breadth, ±0.5 mm) and mass (±0.1 g) soon after laying (using Vernier callipers and a digital pocket balance). Egg volume (*V,* in millilitres) was estimated using the Coulson (1969) formula:

$$V = 0.51 * L * B^2, \quad [1]$$

where *B* is the maximum breadth and *L* is the maximum length (in millimetres) of each egg. To minimize disturbance, as little time as possible was spent in the colony.

Three replacement clutches were identified, but were not considered in the estimates of initial clutch size or subsequent breeding success. The mortality rate of large chicks was difficult to measure because of their tendency to leave the nest when disturbed (Lehikoinen 2006). The number of nearly fledged chicks (more than 30 days post-hatch) was counted at the end of the breeding season to estimate breeding success. According to Krag (2003), the greatest chick loss is after 40 days. Boating searches for dead chicks were made through the colony during and after the breeding activities.

Hatching success was calculated as the proportion of eggs that hatched successfully. Fledging success was calculated as the proportion of chicks that subsequently fledged successfully. Breeding success was calculated as the proportion of eggs that produced fledglings, and nest productivity was calculated by dividing the number of young birds before fledging by the number of nests. The diet of nestlings was determined from five regurgitates collected when we entered the colony. Fish were identified, and their length and mass were recorded. Statistics were calculated using the SPSS software package (SPSS, Chicago, IL, USA). Chi-square analyses were used to test the frequency of clutch size and brood size.

RESULTS

Population status

The breeding population of the Pygmy Cormorant at Siahkeshim wetland was 100 pairs in 2001, 80 in 2003 and 54 in 2007. All nests found in 2001 and 2003 were located around the Bahambar River (37°24′N, 49°23′E). At this wetland, the birds bred in one colony at a mean altitude of 22.5 m above sea level.

Nesting biology

Birds arrived at the colony in the middle of March. Nests were built in trees, in reed beds and in the transition zones between reed beds and open water. All nests were in Willow *Salix* trees with a mean height of 2.95 m [n = 21, standard deviation (SD) = 0.47]. The nests were 25–45 cm in diameter and located in five subcolonies with a mean inter-nest distance of about 50 m (n = 4, SD = 10.2) situated about 3.5 m (n = 5, SD = 1.7) from open water. The number of nests in each subcolony was three, 11, five, 17 and 18. The first eggs were laid on 1–3 April, and the mean laying date was 15–17 April. Table 1 summarizes egg measurements. Fig. 1 shows the frequency of eggs and chicks at fewer and more than 20 days during the study period. The maximum number of eggs were found on 20 April. Hatching started on 20 April, and the median hatching date for the whole colony was 5 May.

Breeding success

The mean clutch size was 4.1 eggs (n = 40, SD = 1.3; median: 4; range: 2–6; Fig. 2), and the mean brood size soon after hatching was 3.6 chicks (n = 38, SD = 0.9; median: 4; range: 2–5). Nests with three small chicks were significantly more numerous than other brood sizes ($\chi^2 = 14$, df = 3, $P < 0.05$), as were nests with three fledglings ($\chi^2 = 8.5$, df = 3, $P < 0.05$; Fig. 2).

In total, 87% of the eggs hatched and 88% of hatchlings reached near-fledgling stage, giving an overall breeding success of 77%. Mean net productivity was 3.2 ± 0.7 fledglings per nest (n = 40, median = 3; range: 2–5) in all nests, and considering only the nests with chicks, mean fledglings per nest was 3.3 ± 0.8 (n = 38). Breeding failure was evenly spread during the breeding season with 55% occurring during the incubation period, 29% during the first 20 days post-hatch and 16% after 20 days post-hatch (G = 1.3, df = 1, $P > 0.05$). In total, 5% of the eggs failed to hatch; other failures were a result of predation or egg loss. Of the 17 chicks lost, 64% were lost during the first 20 days post-hatch.

Chick diet

The nestling diet consisted of *Carassius carassius, Cobitis taenia, Esox lucius, Cyprinus carpio* and *Hypophthalmichthys molitrix*

TABLE 1
Measurements of eggs of Pygmy Cormorant *Phalacrocorax pygmeus* at Siahkeshim, northern Iran, 2007

	N	Mean	SD	Median	Min–Max
Length (mm)	51	45.8	1.1	45.5	44–47.5
Breadth (mm)	51	29.6	1.0	30	28–31
Mass (g)	36	20.3	1.6	19.5	18.5–22.5
Volume[a] (cm^3)	51	20.1	1.7	20.6	17.6–23.3

[a] Calculated according to Coulson *et al.* 1969.
SD = standard deviation.

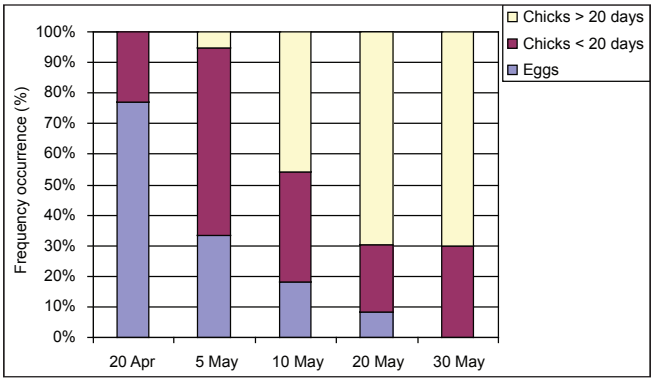

Fig. 1. Breeding phenology stage of the Pygmy Cormorant *Phalacrocorax pygmeus* colony in Siahkeshim Protected Area, northern Iran.

(Table 2). The main species was *Carassius carassius* which constituted 48% by number. Fish given to the chicks varied between 53.5 mm and 160 mm in length, with a median of 50–100 mm. Most of the fish weighed 5–10 g (Table 2).

DISCUSSION

Status and breeding ecology

The Pygmy Cormorant is poorly known and vulnerable, and its population has declined greatly since the second half of the 19th century because of drainage and degradation of wetlands, persecution by fishermen and destruction of breeding colonies (Collar & Andrew 1988). The lack of even basic information on ecology and biology (e.g. age of first breeding, reproductive and survival rates), coupled with a recent population growth and range expansion, and last but not least, recent rising conflict with fish-farmers, have drawn new attention to this bird in several countries (Voskamp *et al.* 2005). The Asian population, which breeds in the Caspian region, Mesopotamia (Iraq and southwest Iran), Kazakhstan, Turkmenistan, Uzbekistan and Tajikistan, is not well known (Scott 1995).

Although breeding of Pygmy Cormorant was never confirmed in Iran in the 1970s, some pairs may have nested at Anzali Wetland in 1972. It also may have nested in the extensive marshes of the Hawr Al Azim in Khuzestan in southwest Iran (Scott 2007). The species is now known to breed in three main locations in Iran: a large breeding population in the Hoor Al Azim marshes in Khuzestan Province, southern Iran (Voskamp *et al.* 2005); one colony in the southern Caspian sea in the Miankaleh Wildlife Reserve (probably fewer than 50 pairs); and one in the Siahkeshim Protected Area in the Anzali wetland (Voskamp *et al.* 2005, Sehhatisabet 2006). In northern Iran, details of the breeding population are not clear, but it occurs in the northern provinces including Giulan and Mazandaran (Porter *et al.* 1996). The colony in Siahkeshim is one of the most important in Iran. This habitat is mainly covered by reed beds, and the cormorants nest in *Salix* trees in varying depths of water depending on the season and climate status.

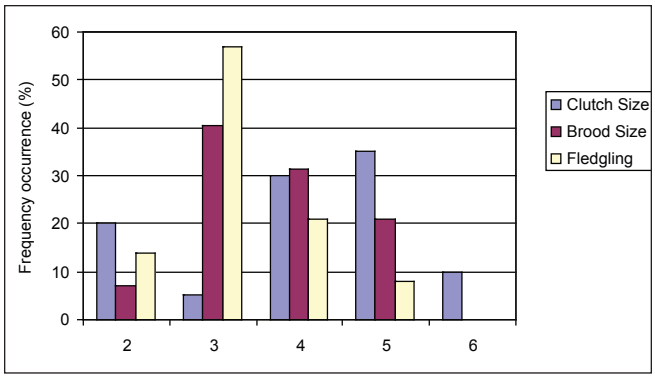

Fig. 2. Percentage of clutch sizes, brood sizes and number of fledglings at the Pygmy Cormorant *Phalacrocorax pygmeus* breeding colony in Siahkeshim Protected Area, northern Iran.

The mean egg volume (20.0 mL) in this study was slightly lower than that of birds from Lake Kerkini in Greece [22.1 mL based on mean length and breadth (Nazirides & Papageorgiou 1996)], but within the range reported by Cramp and Simmons (1977): 28–33 mm. At Siahkeshim, the clutch size ranged from 2–6 eggs (commonest 4–5 eggs) as compared with the Cramp and Simmons (1977) report of 3–7 (4–6) and the Nazirides and Papageorgiou (1996) report of 2–8 (5–6).. The mean chick productivity per nest was 3.2, slightly more than the 2.9 reported by Nazirides and Papageorgiou (1996) in Greece in 1988–1990. The mean hatching success of 87% was also higher than the hatching success of 77% reported from Greece (Nazirides & Papageorgiou 1996).

The chick survival rate of 88% to near-fledging stage that we observed seems to be greater than that in Greece in 1988–1990 (Nazirides & Papageorgiou 1996) and than that of the Great Cormorant *Phalacrocorax carbo* in northern Iran (Barati *et al.* 2007). The rate of loss of eggs or chicks was highest during the incubation and small chick periods, when the nestlings are totally or nearly featherless and depend on the warmth of their parents (Ostens *et al.* 2001), as has been reported to be the case for the Great Cormorant in northern Iran and elsewhere (Krag 2003, Barati *et al.* 2007). Although five fish species were identified in the chick diet (*Carassius carassius, Cobitis taenia, Esox lucius, Cyprinus carpio* and *Hypophthalmichthys molitrix*), the main species was *Carassius carassius,* which constituted nearly half the fish in the diet. This species is a benthic fish that lives in rivers and lakes (Vosouqi & Mostajir 1993) and is one of the most abundant in Siahkeshim wetland (Riazi 1997).

Threats and conservation

The main threats to breeding and wintering Pygmy Cormorants in Iran are anthropogenic. Riazi (1997) mentions drainage and habitat degradation of breeding and wintering habitats as being the main problems for the Siahkeshim Protected Area. In the breeding season, changes in water level may affect breeding efficiency and breeding output in a major way, because decreased levels may allow access by nest predators and increased levels may lead to flooding (Sehhatisabet 2006). However, shooting and destruction of colonies are probably the most important factors causing the

TABLE 2
The frequency of occurrence, mean length and mean mass of fish in five regurgitations of the Pygmy Cormorant *Phalacrocorax pygmeus* in the Siahkeshim Protected Area, northern Iran

Family	Species	Frequency by number (%)	Length (mm) ±1 SD	Mass (g) ±1 SD
Esocidae	*Esox lucius*	18.0	79.8±4	8.7±3
Cobitidae	*Cobitis taenia*	24.0	65.5±12	9.3±2.5
Cyprinidae	*Carassius carassius*	48.0	83.7±8	15.8±3.5
	Cyprinus carpio	3.8	77±13	8.3±4.5
	Hypophthalmichthys molitrix	6.2	130±30	34±17

SD = standard deviation.

decline of the species. Regulation of hunting has been noted as an important factor in the successful conservation of the species in Iran (Balmaki *et al.* 2004, Voskamp *et al.* 2005), and in the Siahkeshim Protected Area, disturbance and shooting is not considered a major threat. However, we do not have information about the status of shooting in winter either within or outside this area. In a waterfowl hunting survey in Giulan province, 83 Pygmy Cormorants were shot between November 2001 and February 2002 (Balmaki & Barati 2006). The presence of this species in the bird markets also indicates that the management of the traditional harvest is extremely difficult because of cultural constraints in Giulan and is not being fully implemented at the present time. It also shows the necessity of expanding monitoring and control to areas outside the protected areas. In some cases, illegal fishing activities may affect feeding Pygmy Cormorants because they may be caught in fishing nets. Contamination by heavy metals may also affect the breeding success of Pygmy Cormorant in northern Iran.

To protect breeding colonies and to increase breeding output, some important conservation measures must be carried out. Effective legislation to protect the species and its habitat from hunting, disturbance and development over a large area is necessary, as is continuous monitoring of wintering and breeding populations, including numbers and distribution. A comparison of the breeding phenology and breeding success of this species in Siahkeshim Protected Area and Minkaleh Wildlife Refuge should be made to address the effects of ecologic factors on breeding strategies. We also suggest the development and implementation of national action plans for the species and for the conservation of its wetland habitats. Public awareness campaigns aimed at hunters, fishermen, local communities, nongovernmental organizations, politicians and civil servants will increase knowledge of the species and provide a baseline for protecting it. Other aspects of Pygmy Cormorant ecology should be investigated, including adult diet, migration patterns and main causes of mortality in adult birds. This information would provide a baseline for effective management and protection of this threatened species in Iran.

ACKNOWLEDGEMENTS

We are grateful to personnel of the Siahkeshim Wetland Game Warden Station for their kind assistance during fieldwork. Derek A. Scott, Ian Harrison and an anonymous reviewer provided useful comments on an earlier draft of the manuscript.

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