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ASPECTS OF THE BREEDING BIOLOGY OF THE RED-LEGGED CORMORANT *PHALACROCORAX GAIMARDI* ON THE ATLANTIC COAST OF SOUTH AMERICA

ESTEBAN FRERE[1] & PATRICIA ALEJANDRA GANDINI[1,2]

[1]*Centro de Investigaciones de Puerto Deseado, Universidad Nacional de la Patagonia Austral, Avda. Lotufo s/n (9050) cc. 238, Puerto Deseado, Santa Cruz, Argentina (rqfrere@pdeseado.com.ar)*
[2]*Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Santa Cruz, Argentina*

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SUMMARY

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Red-legged Cormorants *Phalacrocorax gaimardi* breed in Argentina, Chile, and Peru. In Argentina their breeding range is restricted to a short section of coastline in southern Patagonia. We studied two colonies located on high rocky cliffs, 2 to 4 m above the high tide line. At one colony, nests were protected from prevailing winds whereas at the other colony most of the nests were exposed. Of active nests, 15% had two eggs, 66% had three eggs, and 19% had four eggs, to give a mean clutch size of 3.04±0.47. Egg dimensions were 60.3±2.4 × 37.1±1.4 mm. The incubation period ranged from 34 to 38 days with chicks hatching from mid-November to the first week of December. Red-legged Cormorants lay more and smaller eggs than do those of two sympatric cormorant species, the Rock Cormorant *P. magellanicus* and the Imperial Cormorant *P. atriceps*, probably as a result of differences in foraging ranges. Avian predation on eggs seems to be an important mortality factor for this species and wind has also an important effect on breeding success, possibly exacerbating avian predation.

Keywords: Red-legged Cormorant, *Phalacrocorax gaimardi,* Argentina, breeding biology

INTRODUCTION

The Red-legged Cormorant *Phalacrocorax gaimardi* is found along the Pacific (Duffy *et al.* 1984, Schlatter 1984, Vilina & Gonzalez 1994) and Atlantic coasts (Humphrey *et al.* 1985, Siegel-Causey 1987, Gandini & Frere 1995) of South America. In Argentina its breeding range is restricted to the Santa Cruz Province (Doello-Jurado 1917, Murphy 1936, Zapata 1967, Gandini & Frere 1995). Despite its wide distribution, it is one of the least-studied cormorant species (Siegel-Causey 1987). On the Pacific coast, a preliminary study of the breeding cycle and factors that influence breeding success has been undertaken in the northern part of Chile (Vilina & Gonzalez 1994). On the Atlantic coast, there have been studies of its behaviour (Siegel-Causey 1987), distribution and numbers of breeding colonies (Gandini & Frere 1995, 1998). Given that the Red-legged Cormorant is listed as lower risk/near threatened (BirdLife International 2000) and rare within a restricted breeding range (Grigera & Ubeda 1997), it is important to identify the factors that affect its breeding success. Kelp Gulls *Larus dominicanus* have expanded their numbers over the last few decades in coastal Argentina due to the use of food from refuse tips (Yorio *et al.* 1998). Kelp Gulls have been reported to prey on Imperial Cormorant *P. atriceps* eggs and young (Malacalza 1987, Quintana & Yorio 1998) and competition for nest space has been reported between Imperial and Neotropic Cormorants *P. brasilianus* (Yorio *et al.* 1994). About 93% of the Argentinean Red-legged Cormorants breed near coastal cities, making them vulnerable to Kelp Gulls. Higher mortality from increased opportunistic egg predation by avian predators during windy or stormy weather has been reported for a number of seabird species (Young 1994, Frere *et al.* 1998). Southern Patagonia is characterized by strong winds, especially during spring, when most seabirds are breeding (Frere *et al.* 1998). For those species that breed in open nests on exposed cliffs, weather could be an important determinant of breeding success. We expect pairs breeding in colonies where the effect of the strong winds are reduced by cliffs to have the higher reproductive success. This paper describes the breeding biology of the Red-legged Cormorant in Argentina and studies causes of egg and chick mortality.

METHODS

Study area

Field work was conducted at Puerto Deseado (47°45'S, 65°56'W), Santa Cruz Province, Argentina, between August 1998 and March 1999. The area is characterized by strong winds and a low annual rainfall that does not exceed 200 mm. The Ría Deseado was formerly a river bed that has been inundated by the sea. It is characterized by a rocky shoreline, headlands, cliffs, and islands, some of which are connected to the mainland at low tide. There are six Red-legged Cormorant colonies in the Ría Deseado (Gandini & Frere 1998). We carried out this study at two colonies in the Ría Deseado: Isla Elena (47°45'S, 65°56'W) and Cañadón del Puerto (47°45'S, 66°00'W), located 5 km apart.

Field procedures and analyses

The study area was observed weekly until the cormorants settled and then visited every two to three days after pair formation. We selected 23 nests at Isla Elena and 24 nests at Cañadón del Puerto for detailed study. To evaluate possible effects of disturbance by observers on the breeding success at each colony, a similar number of control nests was observed from a distance of 25 m using 10× binoculars. We climbed the cliffs to reach the study nests to collect data. At each visit we recorded the number of eggs or chicks in the study nests and the number of aerial predators present at the colony. We measured nest orientation, defined as the direction from which the nest was exposed to the wind and not sheltered by the adjacent cliff, using a hand-held compass. Eggs were marked with a number corresponding to their nest and laying order. To quantify egg size, we measured egg length and maximum width with Vernier calipers (±0.1 mm) and mass using a Pesola balance (±0.5 g). By checking the nests every other day during egg laying, we were able to weigh and measure eggs within two days of the time they were laid. The duration of the incubation period was estimated from those eggs for which we had laying and hatching dates. An egg was considered depredated if predation was observed during the periods of field work, or broken shells were found in the nest; if not, the cause of egg loss was considered 'unknown'. Causes of chick mortality were categorized as: 1) starved (chicks found dead in their nests that had a small body size for their age); 2) fallen from the nests (small chicks that disappeared after strong winds or were found dead below the cliff) and 3) unknown (missing chicks).

In both colonies we counted all active nests at the beginning and the total number of fledglings at the end of the season to obtain an independent measure of breeding success. This procedure was also done during 1993/94, 1997/98 and 1999/00. Active nests were those in which at least one egg was laid. Successful nests were those in which at least one chick survived to the first week of January when chicks were approximately five weeks old. Wind directions and velocities (in knots) were obtained from the Argentine Meteorological Service at Puerto Deseado over the study period.

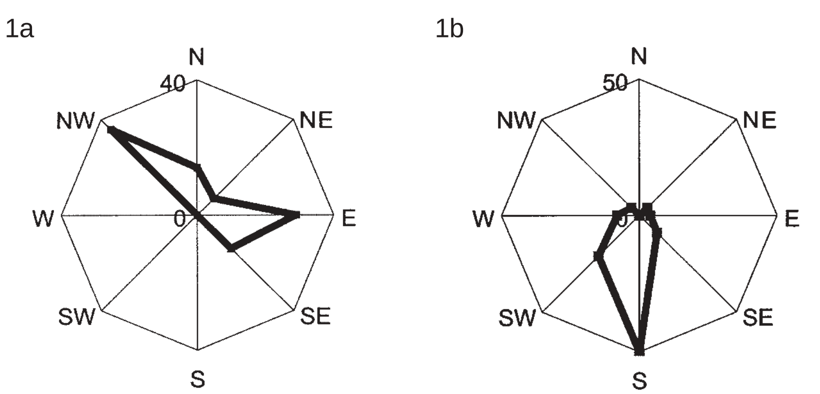
We compared the number of eggs laid and the number of chicks hatched per nest between colonies with a Chi-squared test. To compare variation in breeding chronology between colonies we used a median test and to test differences in nest orientations we used the Watson-Williams test for two samples (Zar 1984). To compare the number of eggs and chicks that died in each colony and the number of fledglings in control versus study nests we used a Chi-squared test. Other statistical tests were also used and this is mentioned with their result (see later).

RESULTS

Nest characteristics and breeding dates

Nests were located on high rocky cliffs, 2–4 m above the high tide line and consisted of fronds of seaweed and guano. Most nests were exposed to wind from the north-west at Isla Elena (Fig. 1a), and from the south at Cañadón del Puerto (Fig. 1b), being different between colonies (Watson-Williams, $F_{1,46} = 60.4$, $P < 0.001$). At Cañadón del Puerto, the nests were protected from prevailing winds whereas at Isla Elena most of the nests were exposed to wind (Fig. 1c).

The total numbers of active nests was 131 at Isla Elena and 65 at Cañadón del Puerto. Both colonies were occupied from 30 August to 14 October 1998. Laying occurred from mid-October to the third week of November, showing considerable asynchrony. Differences in laying dates between colonies were found ($\chi^2_1 = 4.18$,



Figs 1a, b. *Nest orientation of the Red-legged Cormorant at (a) the Isla Elena colony and (b) at Cañadón del Puerto colony. Values are the percentages of nests facing in each direction.*

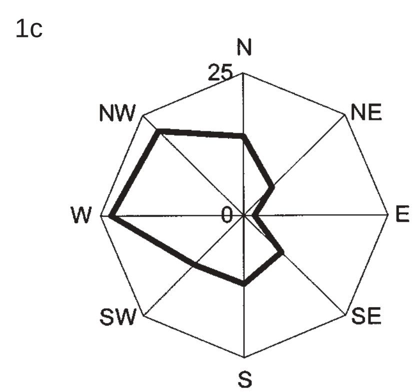


Fig. 1c. *Prevailing winds during the breeding season of Red-legged Cormorant at Puerto Deseado, Santa Cruz, Argentina.*

$P < 0.05$). At Isla Elena the greatest number of eggs was laid on 19 October (median = 18 October), whereas at Cañadón del Puerto, most of the eggs were laid between 13 and 15 October (median = 15 October).

Hatching occurred from mid-November to the first week of December. At Isla Elena, the mean hatching date was 19 November 1998 (median = 18 November), whereas at Cañadon del Puerto the mean hatching date was significantly later on 21 November 1998, (median = 20 November), ($\chi^2_1 = 4.17$, $P < 0.05$).

Eggs, clutch size and incubation

Of 47 active nests, 15% contained two eggs, 66 % had three eggs and 19% had four eggs. Mean clutch size was 3.04 (range: 2–4, n = 24), for Cañadón del Puerto and 3.04 (range: 2–4, n = 23), for Isla Elena ($\chi^2_2 = 3.07$, $P = 0.21$). Mean egg size was 60.3±2.4 × 37.1±1.4 mm (n = 66), and mean mass 47.1 ± 3.3 g, (n = 65). The incubation period varied from 34 to 38 days (mean = 36±1.2 days, n = 19 eggs). No differences in incubation period between colonies were found ($F_{1,17} = 3.55$, $P > 0.05$).

Breeding success and causes of mortality

Egg mortality was higher at Isla Elena than at Cañadón del Puerto (Table 1). At the end of incubation 92% (n = 22) of the nests had at least one egg at Cañadón del Puerto, significantly higher than at Isla Elena 48% (n = 11) ($\chi^2{}_1 = 8.8$, $P < 0.003$). The number of eggs addled against eggs which remained at the end of incubation was also higher at Isla Elena (Table 1, $\chi^2{}_1 = 8.2$, $P = 0.004$) as was the proportion of nests that suffered predation during incubation (48 % compared to 33 %), and overall egg predation (Table 1, $\chi^2_1 = 6.50$, $P < 0.01$). Hatching success was lower at Isla Elena (1.09 ± 1.28 chicks per nest, range 0–4, n = 23) than at Cañadón del Puerto (2.08 ± 0.97 chicks per nest, range: 0–4, n = 24); (Table 1, Mann-Whitney $U = 151.5$, $P < 0.01$).

Of 47 nests (pooled data), 19 were depredated (40%) and nine had addled eggs (19%). In both colonies we saw egg predation attempts by Kelp Gulls and Dolphin Gulls *L. scoresbii*. We observed two predation events by Kelp Gulls at Isla Elena, where six pairs of these gulls were nesting. Other potential egg predators, such as the Black-crowned Night Heron *Nycticorax nycticorax*, frequently flew over the Isla Elena and Cañadón del Puerto colonies. During eight days during the incubation period we recorded 10 Kelp and Dolphin Gulls flying over Isla Elena, whereas we counted a maximum of six gulls at Cañadón del Puerto.

Chick survival at Cañadón del Puerto (18%) and Isla Elena (8%), was not significantly different (Fisher exact test, $P > 0.30$, Table 1). The number of fledglings in our control nests did not differ significantly from that in the study nests ($\chi^2_1 = 0.006$, $P > 0.05$). In the study nests, the mean number of fledglings was 0.08±0.28 per nest at Isla Elena (range 0–1), where only two pairs were successful, but there were 0.37±0.65 fledglings per nest at Cañadón del Puerto (range 0–2) where seven pairs were successful. Considering all active nests at the beginning of the season, breeding success was 0.12 fledged young/nest at Isla Elena and 0.22 fledged young/nest at Cañadón del Puerto. The number of fledged young/nest at Isla Elena was 0.70 in 1993/94, 0.67 in 1997/98, and 0.41 in 1999/00. Of 75 hatched chicks (pooled nests), 64 (85%) died before fledging. Twenty-one small chicks fell out of the nests into the sea after strong winds (28%), nine probably starved (12%), and the causes of death of 34 others (45%) are unknown.

DISCUSSION

This study provides the first description of the breeding biology of the Red-legged Cormorant on the Atlantic coast. Breeding parameters of this species differed between colonies, and from those of other cormorant species in Argentina. Mean clutch size of the Red-legged Cormorant (3.0) was higher than for the Rock Cormorant *P. magellanicus* (2.3, Punta & Saravia 1993) and the Imperial Cormorant (2.4–2.5, Malacalza & Navas 1996, Arrighi & Navarro 1998). At Puerto Deseado 19% of the Red-legged Cormorants laid a clutch of four eggs, whereas less than 3% of clutches of the other two species contained four eggs (Punta & Saravia 1993, Arrighi & Navarro 1998). All egg measurements, especially mass, are smaller than the ones reported by Malacalza & Navas (1996) for the Imperial Cormorant (range 50–80 g, mean 60.3 g). The incubation period was longer for the Red-legged Cormorant (mean 36 days) than for the Imperial Cormorant (28.6 days, Malacalza & Navas 1996). Although Red-legged Cormorants are similar or smaller than sympatric cormorant species in body size and mass (unpubl. data), they lay more but smaller eggs. This variation in clutch size among the three species might result from differences in foraging ranges (Lack 1968), the Red-legged Cormorant being the most inshore forager of the three species at Puerto Deseado (pers. obs.).

TABLE 1

Reproductive parameters of Red-legged Cormorants *Phalacrocorax gaimardi* breeding in Argentina

Colony	Nests	Eggs laid	Egg mortality			Hatchlings (hatching success %)	Fledglings (breeding success %)
			Depredated (%)	Unhatched (%)	Unknown (%)		
Isla Elena	23	70	28 (40%)	11 (16%)	6 (8%)	25 (36%)	2 (3%)
Cañadón del Puerto	24	73	14 (19%)	3 (4%)	6 (8%)	50 (68%)	9 (12%)
Total	**47**	**143**	**42 (29%)**	**14 (10%)**	**12 (8%)**	**75 (52%)**	**11 (8%)**

Red-legged Cormorants on the Atlantic coast commence breeding a month earlier than do Imperial Cormorants (Arrighi & Navarro 1998, pers. obs.) and Rock Cormorants (Punta & Saravia 1993, pers. obs.) and show high asynchrony. Relative timing of breeding might be related to different chronologies of availability of major prey: Imperial and Rock Cormorants prey predominantly on fish (Wanless & Harris 1993, Malacalza *et al.* 1997), whereas Red-legged Cormorants take mainly benthic invertebrates (pers. obs.), which are assumed to be more predictable prey.

Breeding success was highly variable between seasons, being particularly low in 1998/99. Breeding success was 8%, with high egg and chick mortality. Predation seems to be an important egg mortality factor for this species, being higher at Isla Elena where the number of predators (Kelp and Dolphins Gulls) was higher. This colony is also more exposed to wind, where nesting adults may be distracted or oriented in a particular direction, facilitating prey capture during days of strong winds, as was suggested by Young (1994) for penguins. The fact that Isla Elena nests were the most exposed to wind could also cool the eggs during incubation, perhaps explaining the number of addled eggs at this colony, and also might explain the higher chick mortality. Vilina & Gonzalez (1994) reported on the Pacific coast that exposure to wind has a strong influence on breeding success. On the Atlantic coast winds also have an important effect and might increase avian predation.

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