Short Communications

Nest Predation by Corvids on Cormorants in Australia

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Cormorants *Phalacrocorax* sp. consume commercially important species of fishes (Pilon et al. 1983; Carroll 1988; Kennedy & Greer 1988; Carss & Marquiss 1992). Accordingly, there is considerable interest in the impact of cormorants on populations of prey and the possibility of regulating numbers of these birds (e.g. Moerbeek et al. 1987). Policy focus in Australia has centred primarily on eradication or exclusion of individuals (R.T. Kingsford pers. comm.) and less on understanding their ecology and factors determining population size and distribution.

Nest predation is well known to be of great importance to many species of birds, not only in terms of population regulation, but also in nesting distribution (Page et al. 1985; McKilligan 1987; Møller 1989; Singer et al. 1991) and nesting density (Page et al. 1983; Sugden & Beyrsbergen 1986). Although isolated incidents of predation on adult cormorants by turtles (Suborder Cryptodera; Sivasubramanian 1986) and Black-backed Jackals *Canis mesomelas* (Hiscocks & Perrin 1987) have been recorded, nest predation is likely to be a more important influence. Nest predation by American Ravens *Corvus corax* was linked to the decline of the Double-crested Cormorant *Phalacrocorax auritus* in the central United States of America (Grant 1970; Post 1988). At Tatoosh Island, Washington, USA, a population of Pelagic Cormorants *P. pelagicus* and Common Murres *Uria aalge* increased markedly as nest predation by Northwestern Crows *C. caurinus* diminished when Peregrine Falcons *Falco peregrinus* immigrated to the area (Paine et al. 1990). Although the distribution of cormorants is likely to be related to abundance of food (Miller 1979; Gosper et al. 1983; EJD unpubl. data), fluctuations in population size may be substantially affected by nest predation (Grant 1970; Paine et al. 1990).

Although nest predation by corvids has been mentioned for cormorants in Australia (Marchant & Higgins 1990), the phenomenon appears to have been observed more often than it has been reported. Without these observations, the occurrence of nest predation on Australian cormorants may be overlooked and its importance to cormorant population dynamics underestimated. In this paper, we review observations of nest predation on cormorants in Australia by Little Crows *Corvus benetti* and Australian Ravens *C. coronoides*. We also present data from a monitoring program which was initiated as an attempt to observe and assess some of the circumstances in which nest predation may occur in a colony of Little Pied Cormorants *Phalacrocorax melanoleucos* in Sydney. Our findings suggest that greater focus should be given to the role of predation in the population regulation of cormorants.

Methods

Observations of nest predation

Nine incidents of nest predation were gathered from the literature, by personal communication with witnesses, or by direct observation. The sightings of corvids preying on cormorant nests were made either on foot or by small boat, during studies of the nesting behaviour of other species such as Great Egrets *Ardea alba* (Pedler 1978), as incidental observations during wetland censuses, or as part of a study on cormorant biology. Observations were made on the coast and inland and were not restricted to a particular time of year.

Monitoring of a nesting colony

In 1993, eight pairs of Little Pied Cormorants established a nesting site in a stand of *Casuarina glauca* on an island in an artificial lake in Bicentennial Park, along the Parramatta River, Sydney. The island on which the birds nested was approximately 88 x 25 m in area and was isolated from shore by at least 40 m. Nests were between 2 and 3 m above the ground. Contents were examined with a mirror mounted on a pole once at the beginning of the nesting season and once after nesting was completed. Six other sets of observations were made from shore, with binoculars.

At the beginning of the nesting season, the island was inspected for scats, tracks or other evidence of resi-

Table 1 Observations of nest predation on cormorants.

Cormorant species	Predator	Location	Source	Date
Phalacrocorax melanoleucos	*Corvus coronoides*	Port Broughton, SA	Pedler (1978)	20 Jan. 1974
P. melanoleucos	*C. coronoides*	Lake Brewster, NSW	B. Miller (unpubl. data)	May 1974
P. melanoleucos	*Corvus* sp.	Lake Menindee, NSW	P. Masters (pers. comm.)	Sept. 1980
P. melanoleucos	*C. coronoides*	Newcastle, NSW	G. Baxter (pers. comm.)	Jan. 1987
P. varius	*C. coronoides*	Lake Apanburra, SA	J. Reid (pers. comm.)	Feb. 1990
P. sulcirostris	*Corvus* sp.	Lake Gregory, WA	R.T. Kingsford (pers. comm.)	Aug. 1991
P. melanoleucos	*Corvus* sp.	Coorlay Lagoon, SA	JR (pers. obs.)	2 Feb. 1992
P. melanoleucos	*Corvus* sp.	Coorlay Lagoon, SA	R. Ebdon (pers. comm.)	29 Mar. 1992
P. sulcirostris	*C. benetti*	Coorlay Lagoon, SA	R. Ebdon (pers. comm.)	6 Mar. 1993

dent mammalian predators, such as cats or rats. The depth of water and distance to shore would probably have precluded travel by cats to and from the island and the nests were too high for access by dogs or foxes, so that we believe that only avian predators could reach the nests.

Results

Direct observations

In all cases where corvids were observed at the nest, predation appeared to be facilitated by observer presence, that disturbed cormorants from their nests. When predation on eggs was observed, the corvids carried the eggs unbroken from the cormorant colony (R. Ebdon pers. comm.; P. Masters pers. comm.; Julian Reid pers. comm.; JR pers. obs.). Observations showed that nest predation was not restricted to a single cormorant species, geographical location or habitat type. In half of the cases, it was not possible to identify the species of predator (Table 1).

Monitoring

At the beginning of the breeding season, seven of the eight nests contained eggs (mean = 2.25 eggs per nest, *s.e.* = 0.46, range = 0-4) and two Australian Ravens, which had not been observed previously during four months of censusing, took up residence in the trees. During six subsequent observation periods spaced throughout the nesting season, at least one raven was present at all times, directly above the nesting birds. No nest predation was observed; however, no young were raised. After the cormorants had left the area, we could find no eggs, egg shells or dead chicks, as would have been expected had the eggs either been consumed by mammals or the chicks had fallen from the nests.

Discussion

The most noticeable similarity among the direct observations of nest predation was the element of human disturbance. Human disturbance is a key factor producing bias in bird studies (see review by Götmark 1992). Tourists and researchers visiting a colony can considerably lower the success of nesting seabirds. Disturbance to California Brown Pelicans *Pelicanus occidentalis californicus* and Heermann's Gulls *Larus heermanni* in the Gulf of California rendered chicks vulnerable to attack by conspecifics, Western Gulls *L. occidentalis* and ravens *Corvus* sp. (Anderson & Keith 1980). Similarly, eggs and chicks of Double-crested Cormorants in the St. Lawrence Estuary, Canada, were consumed by gulls more in disturbed nests than in undisturbed ones (Ellison & Cleary 1978).

No disturbance by humans was observed during our monitoring study. The island was inaccessible to the public, therefore it was likely that effects from human activity were minimal. The lack of observed predation at Bicentennial Park may mean that the nests failed for some other reason; however, the absence of egg or chick remains suggests that eggs were taken off the island and consumed. Without human disturbance, the window of opportunity for the ravens was probably small and nest predation an event which occurred too infrequently to be observed using our sampling scheme.

However, with only eight nests in the colony, even rare predation could have been enough to result in complete nesting failure.

The behavioural plasticity of corvids (e.g. O'Neill & Taylor 1984; Tomback 1986; Brown & Veltman 1987) may allow them to take advantage of nesting episodes (Rowley & Vestjens 1973), learning to take eggs or even young on the rare occasions when adult birds are away from the nest or are less vigilant. Australian Ravens have been observed to have an adaptable hunting strategy when preying cooperatively on young Great Egrets (Baxter 1988) and to occupy areas near egret colonies, waiting for the opportunity to prey on nestlings (G.S. Baxter pers. comm.). Their ability to take effective advantage of small windows of opportunity may explain corvids' regular association with cormorant nesting colonies (Post 1988; this study). This may also indicate that a small number of corvids can potentially have a large impact on nesting populations. For example, in the summer of 1981–82, a pair of Torresian Crows *Corvus orru* took 54 eggs from a nesting colony of Cattle Egrets *Ardea ibis* in south-east Queensland, accounting for 46% of eggs lost that season (McKilligan 1987).

Intensive study such as that of Ellison & Cleary (1978) or Anderson & Keith (1980) would be necessary to quantify corvid predation on nesting cormorants. Understanding their population dynamics needs to be combined with knowledge of predator distribution and an assessment of human disturbance. We agree with Paine et al. (1990) who suggest that more attention be paid to corvids in the vicinity of seabird nesting colonies because of the substantial effect they may have on nesting success.

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Location of Colonies in Royal Penguins *Eudyptes schlegeli*: Potential Costs and Consequences for Breeding Success

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The factors affecting breeding success in seabirds has been the topic of debate for many decades (Lack 1954). One important variable is location of nesting sites within colonies (Tenaza 1971; Oekle 1975; Ainley et al. 1983). Another is colony size, with birds in small colonies the least successful (e.g. in some penguin species, Robertson 1986). However, little attention has been paid to the location of a penguin colony (aside from some Antarctic colonies, such as Emperor Penguins *Aptenodytes forsteri*, Robertson 1994), its distance from the water and consequent extra energetic cost to breeding penguins. At Macquarie Island, Royal Penguin *Eudyptes schlegeli* colonies are found at a variety of altitudes from sea level, to sites approximately 200m above sea level (e.g. at Caroline Cove). The added energetic burden of colonies located away from the beach is yet to be assessed.

Taking into account the number of times that an individual penguin needs to return to its nest over a breeding season, the distance and altitude of a colony from the water could substantially increase the total energetic cost of breeding, and possibly affect the breeding success of individuals. It was with this question in mind that we monitored the time taken for Royal Penguins to travel to an inland colony. From the shortest and longest time taken by Royal Penguins to reach the colony, we attempted to assess some of the factors which might affect the variation in time taken. These data were used to calculate a hypothetical energetic cost to the penguins due to the location of this colony and to assess whether location might impact on breeding success.

Methods

The study was carried out at the upper Sandy Bay colony, on the eastern side of Macquarie Island (54°33′57″S; 158°54′57″E). The colony is 1.43 km inland and