Corella, 2003, 27(3): 85–89

SPATIAL AND TEMPORAL ASPECTS OF NESTING AND NESTING SUCCESS OF DARTER AND THREE CORMORANT SPECIES IN SOUTH-EASTERN QUEENSLAND

NEIL McKILLIGAN

Faculty of Sciences, University of Southern Queensland, Toowoomba, Queensland, Australia 4350

Received: 13 October 2002

Great Cormorant *Phalacrocorax carbo*, Little Black Cormorant *Phalacrocorax sulcirostris*, Little Pied Cormorant *Phalacrocorax melanoleucos* and Darter *Anhinga melanogaster* nested at Lake Clarendon, south-eastern Queensland for four years after the lake filled until it fell below 12 per cent capacity. In contrast to some other parts of Australia there was a distinct seasonality in their nesting here, with the Great and Little Black Cormorant nesting in the cooler months of the year and the Little Pied Cormorant in spring and summer. Darter nested throughout the year but mostly in spring and summer. Nest site heights and spacings differed among species. Great Cormorant mostly had high, exposed, well separated nests, whereas the smaller cormorant species nested close together in low, bushy trees. The Darter also nested low but used both bushy and open trees and could be close to or distant from nearest neighbours. The Darter and to a lesser extent the Great Cormorant had high nesting success and these nests fledged 2.4 and 1.8 young on average, respectively. Nesting failures among the cormorants were associated with early or late nesting or, eventually, low water level, but these do not explain the massive losses suffered by the Little Pied and Little Black Cormorants. Although there is no direct evidence, the circumstances surrounding their disappearance point to losses to aerial predators and not starvation, falling from the nest or disease.

INTRODUCTION

Flooding of their freshwater habitats correlate strongly with cormorant and Darter abundances although the association is complex and differs among species (Briggs *et al.* 1998). The feeding and breeding ecology of the Little Black Cormorant *Phalacrocorax sulcirostris*, and Little Pied Cormorant *Phalacrocorax varius* have been studied by Miller (1979, 1980) and of the Darter *Anhinga melanogaster* by Vestjens (1975), at lakes in inland New South Wales. The food of these three species has also been studied in tropical Australia where it may differ in composition from that of temperate Australia (Dostine and Morton 1988, 1989). Much remains to be learned of the breeding biology of the Great Cormorant *Phalacrocorax carbo* in Australia (Marchant and Higgins 1990) but there is some information on this species overseas (Johnsgard 1993). The Little Pied Cormorant mainly eats aquatic invertebrates whilst the other species are mainly piscivorous (Barker and Vestjens 1989). The nest sites of these four species are widely dispersed over Australia and consequently subject to different seasonal and irregular water regimes that may explain the regional differences in the timing of their breeding described by Marchant and Higgins (1990). At Lake Clarendon in south-eastern Queensland, these species nested annually from 1996 to 2000, allowing for an extended study of a mixed heronry. Information was gathered on the location of nest sites, timing of nesting, nest numbers and nesting success in relation to changing water levels and potential predators of eggs and chicks. The nesting and predatory activities of a resident pair of White-bellied Sea-Eagles *Haliaeetus leucogaster* were recorded also.

STUDY SITE AND METHODS

Lake Clarendon (152°27'E, 27°30'S) was originally a shallow water body that was dammed in 1991. It filled for the first time in July 1996, flooding approximately 10 hectares of forest and killing the trees. Darter and cormorant nests were discovered at an advanced stage in these trees in December 1996. Water levels were measured mid-monthly at Lake Clarendon and nearby Atkinsons Lagoon and were provided by the Queensland Department of Natural Resources and Mines.

The nest trees were accessed by canoe and observed through 12 × 50 binoculars. The number of active (i.e. those with attendant adults and/or with young) nests for each species was counted. When present in large numbers some nests would have been overlooked or even counted twice, giving only an approximate number. Nest heights and inter-nest distances were estimated not measured. A mirror on a pole was used to ascertain the contents of accessible nests up to 3 metres above water level. The majority of nests were out of reach but a bird sitting on a nest was taken as evidence for the presence of eggs or young chicks. Chicks older than about two weeks post hatching were not approached any closer than approximately 30 metres. A closer approach causes them to jump into the water where their chances of survival are poor (Vestjens 1975). From this distance a clear view could usually be obtained of the Darter and Great Cormorant advanced broods (upwards of four weeks old) and their sizes were noted, but because the broods of the Little Pied and Little Black Cormorant were often in closely adjacent nests, partly obscured by vegetation it was difficult to count the chicks. Broods at the nests of latter two species were simply recorded as being present or absent.

RESULTS

Lake Clarendon filled to 90.9 per cent capacity in July 1996 then fell progressively to 12 per cent by December 1998, rose to 30 per cent in April 1999 and fell again to below 12 per cent after June 2000, leaving all the nest trees on dry ground (Fig. 1). Water levels changed at Atkinsons Dam in parallel with those at Lake Clarendon, as did levels at many other local lagoons and dams used by Darter and cormorant.

Nesting was monitored each month from December 1996 to December 2000, except for four of the months in 1997 and one in 1999 (Fig. 2). At most, there was a two-month separation between visits ensuring that all successful nesting attempts were detected and nesting stage could be

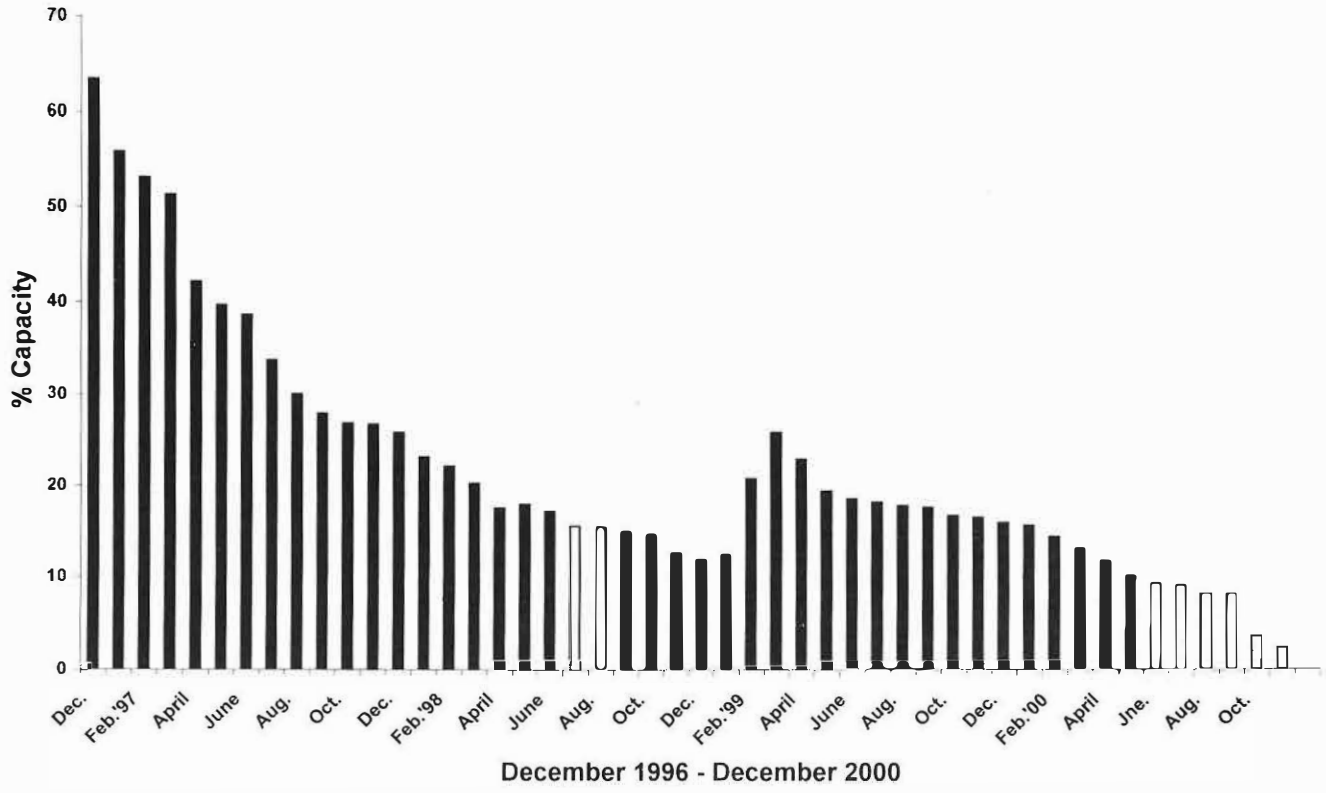

Figure 1. *Lake Clarendon's water volume as a monthly percentage of full capacity, Dec. 1996—Dec. 2000. The open bars represent months when there were no active nests of the four species on the lake.*

determined for 'missing' months by extrapolation. Each species fledged young in 1997, 1998 and 1999, but only the Darter and Little Pied Cormorant did so in 2000 (Fig. 2).

Spatial distribution of nests

All active nests were in dead trees standing in water. Nest trees left on dry ground as the water receded were not re-used. Most Great Cormorant nested high (approximately 15–25 m) in the crowns of dead gum trees, with a few much lower, down to 0.5 metres above the water level, where a substantial stump or fallen limb was available to support the nest. The Little Black and Little Pied Cormorant nested in small bushy trees. The Darter nested in both bushy and open structured trees. The latter three species had nests ranging from one to six metres above water level. The Little Pied and Little Black Cormorant nests were typically closer than one metre whereas the nests of the Great Cormorant and Darter were often many metres from their nearest neighbours. The pair of White-bellied Sea Eagles had the same nest each year. This was about 18 metres up a large dead tree that was only about 12 metres from trees with the nests of the other species.

Timing of nesting and number of nests

Most Darter nested over summer and autumn, but nests with eggs were found in every month except July and advanced young in every month except August (Fig. 2). Their numbers were greatest in March 1998 (48 active nests) and high again in February 2000 (Fig. 3).

The breeding seasons of Great and Little Black Cormorant extended over the cooler months of the year (Figs 3 and 4 respectively), except in 1996 when the Great Cormorant still had advanced young in December. This lateness may have resulted from a later start to nesting after the lake filled in July 1996. Great Cormorant nest numbers peaked at roughly 140 nests in August 1997, but were substantially lower in subsequent years. Little Black Cormorant numbers peaked at about 140 nests in July 1997 and again in July 1999 despite the water level being much lower then (Fig. 1).

Little Pied Cormorant nested over spring and summer. They had about 68 nests in December 1997 but their numbers were usually much lower (Fig. 4).

Nesting success

An unsuccessful nesting month is defined here as one where none of the eggs of that species recorded in that month at the colony subsequently gave rise to fledgelings. Thus defined, Great Cormorant had two unsuccessful months, Little Black Cormorant five and the Little Pied Cormorant two; but the Darter had none (Fig. 2). On these occasions the nests were abandoned at the egg and small nestling stages. In each year these unsuccessful starting months were on the margins of the species' main nesting season. Successful re-nesting occurred each year except for the Little Black and Great Cormorant in 2000. By June 2000 the lake was at only 12 per cent capacity and reducing, causing the water to withdraw from all the nest trees.

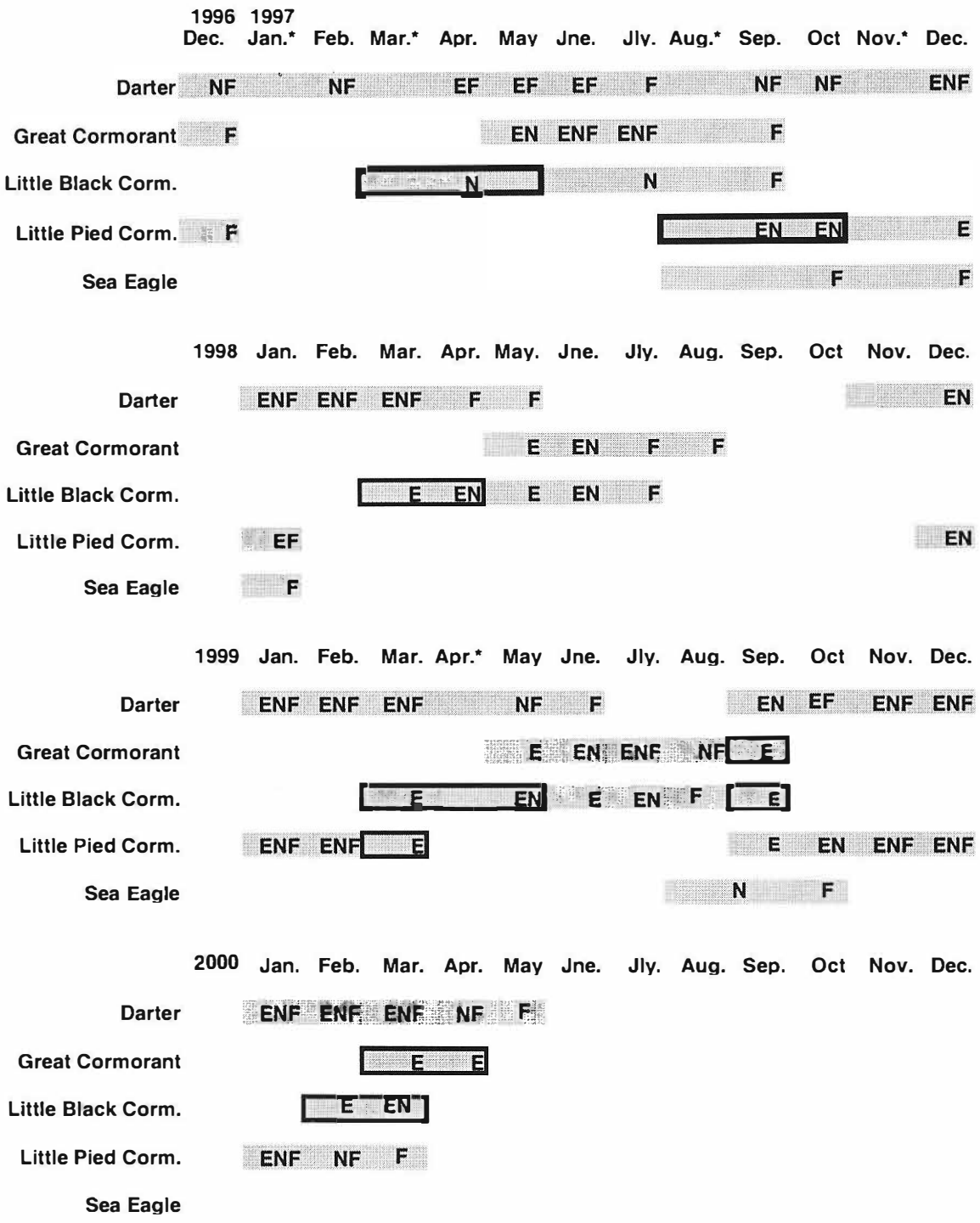

Figure 2. *Months of nesting (shaded) showing observed developmental stages (Egg, Nestling, Fledgling/Fledged). Boxed nesting attempts were unsuccessful.*
** Month of no visit.*

Even when some of their nests had success the two smaller species suffered massive brood losses. For example, the Little Black Cormorant had 46 nests with birds sitting in May 1998 but advanced young were subsequently seen in only six nests. Out of 68 nests of Little Pied Cormorant with eggs or nestlings in December 1997 only two were verified as having advanced young in January 1998.

Largest clutches were four eggs for the Darter, five for the Great and Little Pied Cormorant and six for the Little Black Cormorant. Mean size of advanced broods of Darter was 2.42 (s = 0.917, n = 67) and there was no difference between the annual means. Mean size of advanced broods of Great Cormorant was 1.76 (s = 0.633, n = 47).

Potential predators and causes of mortality

There was no evidence of egg loss or infertility or mass starvation or sickness of chicks. On one occasion a Torresian Crow *Corvus orru* took the eggs from a Darter's nest after I had disturbed the sitting bird. Only three Little

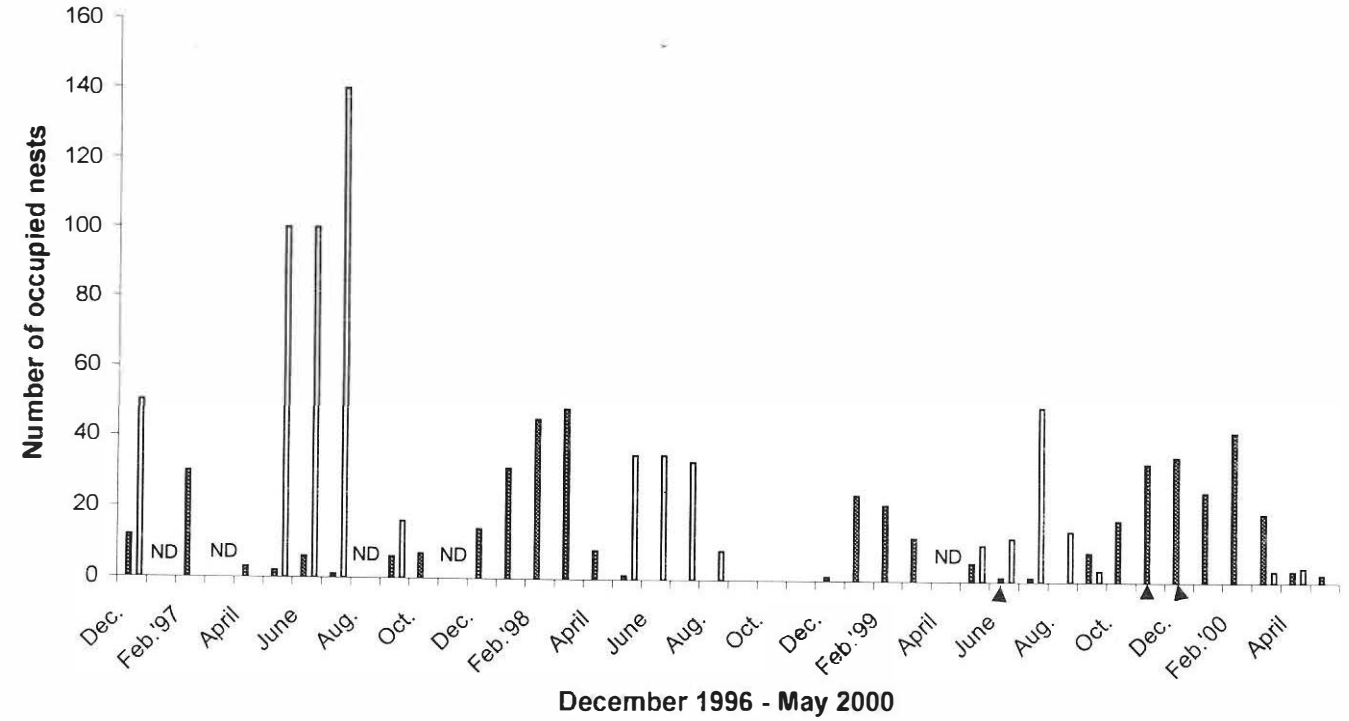

Figure 3. *Nest numbers of Great Cormorant (open bars) and Darter (dark bars). ND = no data. Black triangles on the x-axis indicate total failure of those nests.*

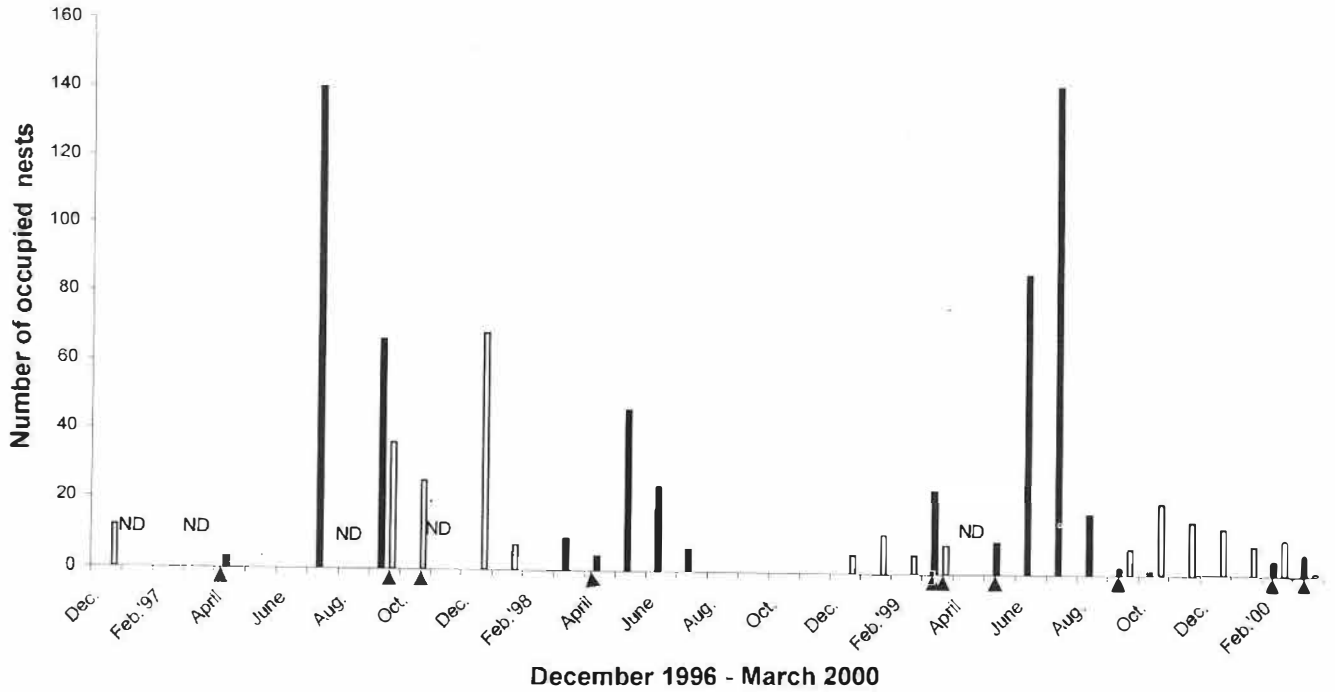

Figure 4. *Nest numbers of Little Black Cormorant (dark bars) and Little Pied Cormorant (open bars). ND = no data. Black triangles on the x-axis indicate total failure of those nests.*

Black and two Little Pied Cormorant chicks and one Darter chick were found dead in the heronry. The cause of death was not apparent. The White-bellied Sea-Eagles were seen on most visits to the heronry. They fledged one chick in October 1997 and a juvenile eagle was present until January 1998. They did not nest in 1998. In 1999 two chicks were seen in the nest in September and one was flying in October. It was not seen in subsequent months. The adults did not nest in 2000. An adult sea eagle was seen catching and eating a Eurasian Coot *Fulica atra* at the lake on two occasions and both the adults and juvenile eagles spent time perching close to cormorant nests. Whistling Kites *Haliastur sphenurus* also perched in the heronry.

DISCUSSION

Of these three cormorant species and darter, Marchant and Higgins (1990) say that nesting 'Probably occurs at any time of the year depending on conditions of water, food and shelter'. Nevertheless a distinctly seasonal pattern of nesting was apparent for these species at Lake Clarendon against a background of (almost) continuously favourable water conditions and plentiful nest sites from mid-1996 until mid-2000.

The Little Pied Cormorant nested in spring and summer at Lake Clarendon, at Toowoomba (40 km west of Lake Clarendon) and in inland New South Wales (Miller 1980). This timing may be influenced by prey availability as its main prey, crayfish, is less available at Toowoomba in the cooler months (pers. obs.) and a winter food shortage is also suggested for inland New South Wales (Miller 1979). Miller (1980) proposes day length as a proximate stimulus to nesting of this species, but apparently this is not the case in the Northern Territory where it nests in late summer at the height of the wet season (Chatto 2000).

Great and Little Black Cormorant nested in the cooler months of the year at Lake Clarendon, whereas Miller (1980) found the Little Black Cormorant nesting in New South Wales only in summer after flooding and not throughout winter, when fish were less available. Water temperatures are higher at Lake Clarendon than at Miller's study site and this may influence the seasonal availability of the Little Black Cormorant's prey. In the Northern Territory this species nests in late summer with the Little Pied Cormorant (Chatto 2000).

The numbers of nesting Great and Little Pied Cormorant showed a general correspondence to water levels, but in 1999 the Darter and Little Black Cormorant had a second peak in numbers about equal to their first nesting after the lake refilled to only half its previous level. Apparently variations in water level alone cannot explain the seasonality in the nesting at Lake Clarendon, the different seasons used by the different species nor the difference here compared with the same species in some other parts of Australia.

The main causes of chick mortality in the Double-breasted Cormorant *Phalacrocorax auritus* in Canada were avian predation, displacement of chicks from the nest and starvation from sibling competition (Kuiken *et al.* 1999). Avian predation of advanced chicks might explain the massive loss of advanced broods of Little Pied and Little Black Cormorant at Lake Clarendon, although direct evidence is lacking. Cormorant chicks are left unguarded from about three weeks posthatching and despite their nests being quite close to one another and possibly gaining some mutual protection, chicks of the small cormorant species would seem to be easy prey to large raptors. In this area the White-bellied Sea-Eagle and Wedge-tailed Eagle *Aquila audax* have been observed taking advanced Cattle Egret chicks directly from their nests (pers. obs.). At Lake Clarendon the Sea-Eagles were especially well placed to prey on cormorant chicks and they always had the choice of the smaller, easier prey. By contrast the bill of a four-week old darter is a formidable weapon! Displacement from the nest and starvation seem less likely causes of mortality as few dead chicks were found, and according to Johnsgard (1993) starvation kills chicks younger than these and results in brood reduction rather than brood elimination.

ACKNOWLEDGMENTS

I am grateful to the Queensland Water Resources Commission for permission to access the Lake Clarendon heronry and the supply of water level data. I greatly appreciate the ongoing financial support of the University of Southern Queensland and field assistance from Helen McKilligan. The paper benefited from the very useful suggestions for improvement made by two referees.

REFERENCES

Barker, R. D. and Vestjens, W. J. M. (1989). 'The Food of Australian Birds 1: Non-Passerines'. (CSIRO, Melbourne.)

Briggs, S. V., Lawler, W. G. and Thornton, S. A. (1998). Relationships between control of water regimes in River Red Gum wetlands and the abundance of waterbirds. *Corella* **22:** 47–55.

Chatto, R. (2000). 'Waterbird Breeding Colonies in the Top End of the Northern Territory'. *Technical Report 69*. (Parks and Wildlife Commission of the Northern Territory, Palmerston.)

Dostine, P. L. and Morton, S. R. (1988). Notes on the Food and Feeding Habits of Cormorants on a Tropical Floodplain. *Emu* **88:** 263–266.

Dostine, P. L. and Morton, S. R. (1989). Food of the Darter *Anhinga melanogaster* in the Alligator Rivers region, Northern Territory. *Emu* **89:** 53–57.

Johnsgard, P. A. (1993). 'Cormorants, Darters and Pelicans of the World'. (Smithsonian Institution Press, Washington.)

Kuiken, T., Leighton, F. A., Wobeser, G. and Wagner, B. (1999). Causes of morbidity and mortality and their effects on reproductive success in double-crested cormorants from Saskatchewan. *J. Wildl. Diseases* **35:** 331–346.

Marchant, S. and Higgins, P. J. (Eds) (1990). 'Handbook of Australian, New Zealand and Antarctic Birds. Vol. 1 Part B Australian Pelican to Darter'. (Oxford University Press, Oxford.)

Miller, B. (1979). Ecology of the Little Black Cormorant *Phalacrocorax sulcirostris*, and Little Pied Cormorant *Phalacrocorax melanoleucos*, in Inland New South Wales I. Food and Feeding Habits. *Aust. Wildl. Res.* **6:** 79–95.

Miller, B. (1980). Ecology of the Little Black Cormorant *Phalacrocorax sulcirostris*, and Little Pied Cormorant *Phalacrocorax melanoleucos*, in Inland New South Wales II. Proximate Control of Reproduction. *Aust. Wildl. Res.* **7:** 85–101.

Vestjens, W. J. M. (1975). Breeding behaviour of the Darter at Lake Cowal, NSW. *Emu* **76:** 121–131.