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CLUTCH SIZE AND FLEDGLING SUCCESS OF THE AUSTRALIAN WHITE IBIS *Threskiornis molucca* IN AN URBAN ENVIRONMENT

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The Australian White Ibis *Threskiornis molucca* is very successful in adapting to and surviving in urban environments. Overabundant and/or large, permanent populations have established in many urban areas of coastal eastern Australia. In urban areas, the Australian White Ibis is currently regarded as a major pest and many agencies aim to reduce its numbers, however, the lack of knowledge on this species has made management difficult. In this study clutch size and fledgling success of Australian White Ibis breeding in Centennial Park, a large urban park in Sydney, were measured. Mean clutch size was 2.70, with a modal clutch size of three. Mean number of fledglings per successful (nestlings hatched) nest was 2.64. While clutch sizes were similar to those reported for ibis in natural and non-urban environments, fledgling success was considerably higher in Centennial Park. This is most likely due to high food availability in urban areas. Management of artificial food sources (e.g. landfills) might be necessary for successfully managing ibis in urban environments.

INTRODUCTION

The Australian White Ibis *Threskiornis molucca* is a native, medium to large-sized wading bird whose distribution range has increased since European settlement (Blakers *et al.* 1985; Marchant and Higgins 1990). Increases are particularly obvious in eastern Australia beginning around 1950 (Morris 1983; Ross 2004). Ibis occur now throughout most of Australia except the arid interior (Marchant and Higgins 1990). Natural habitats for ibis include freshwater wetlands and some marine environments (i.e. intertidal mudflats, estuaries, mangrove wetlands) (Marchant and Higgins 1990). Ibis also use grasslands and irrigated agricultural areas. In urban areas they inhabit open space areas (e.g. parks, picnic grounds, zoos and landfills) (Marchant and Higgins 1990; Lowe 1999; Perry 2001). Ibis are colonial breeders and predominantly nest close to water bodies (Cowling and Lowe 1981; Marchant and Higgins 1990; Perry 2001). Breeding is influenced by the presence and abundance of water, and flooding can stimulate breeding (Carrick 1962; Kingsford and Johnson 1998). Davis and Reid (1974) found that a lagoon reaching maximum volume triggered breeding, and in River Red Gum *Eucalyptus camaldulensis* wetlands, inundation of nest trees is needed to initiate breeding (Briggs *et al.* 1997; Briggs and Thornton 1999). Kentish (1999) also reports that the number of nestlings in a breeding colony is positively correlated with the water level during the preceding month, when copulation occurs, while ibis abandon nests after large drops in water levels (U. Munro, unpubl. data).

Males and females share nesting and brooding duties (Marchant and Higgins 1990). Eggs are laid approximately two to three days apart and hatch asynchronously (Lowe 1984; Beilharz 1988). Incubation takes 20 to 23 days (Lowe 1984) and young are semialtricial and nidicolous. The young remain in the nest for approximately three weeks. From then on they are quite mobile and temporarily leave their nest and form crèches (Marchant and Higgins 1990). Fledging and final abandonment of the nest occurs between 30 and 48 days of age, with a remaining mean period of dependence on parents of 21.5 days after first flight (Marchant and Higgins 1990). Eventually fledglings leave their natal area dispersing widely, and covering hundreds to thousands of kilometres (Lowe 1984; Marchant and Higgins 1990; Lowe 1999). Juveniles reach maturity and commence breeding when approximately three years old (Marchant and Higgins 1990).

The species' behavioural plasticity, flexibility in habitat selection and tolerance to humans has led to permanent and/or overabundant populations in many urban areas, including where ibis were once absent or uncommon (Bekle 1982; Lowe 1999; Ross 2004; Shaw and Murray 2004). Today the ibis is regarded as a major pest in urban areas as they: (1) damage terrestrial and aquatic environments through suppressing and killing vegetation, and polluting and fouling water bodies (Kentish 1994, 1999; Shaw and Murray 2004); (2) compete with and kill native wildlife (Bekle 1982); (3) may carry and transmit diseases that are potentially transmittable and dangerous to humans and animals (e.g. avian influenza, Salmonella and Newcastle disease) (Ross 2004); (4) are a major hazard to aircraft and passenger safety when near airports (Australian Transport Safety Bureau 2002; Corben 2003); and (5) are a general nuisance in open space areas, scavenging from bins, dispersing litter, and harassing and stealing food from people (Hancock *et al.* 1992; Lowe 1999; Ross 2004).

Consequently, there is a need to manage ibis in urban areas. Current ibis management practices include culling, egg and nest removal, scaring and dispersing ibis from roosts and landfills, trapping, habitat modification and public education (Corben 2003; Ross 2004; Shaw and Murray 2004). However, due to the lack of knowledge on ibis, little is known about the effectiveness or impacts of these management practices. Since the ibis is a native

species, it is necessary to assure that management practices do not harm the species and endanger its survival. Ibis management currently favours egg and nest destruction with the aim to reduce overall numbers (Ross 2004). This practice is employed despite poor knowledge on basic reproductive parameters (i.e. clutch size, fledgling success, breeding behaviour) of ibis. Today our knowledge on ibis reproduction is almost entirely based on two studies, which took place at ibis colonies in natural habitats and irrigated agricultural areas throughout south-eastern Australian, and semi-agricultural and rural-suburban lands (i.e. Healesville Sanctuary, Victoria) (Lowe 1984; Beilharz 1988; for summary see also Marchant and Higgins 1990) rather than urban environments. Therefore, the aim of this study was to investigate the breeding biology of the ibis in an urban area and provide baseline data for management purposes. Specifically we focused on clutch size and fledgling success, and compared these parameters to those obtained on non-urban ibis.

METHODS

Study site

The study was conducted at Centennial Park, a large urban park (360 ha) within Sydney. The park is situated approximately five kilometres south-east of Sydney's central business district and seven kilometres north-east of its international airport. The park is a major roosting and breeding site for ibis in Sydney (Roberts 1993; Ross 2004) with at least 1 000 ibis present during the breeding period in 2003 (Corben 2003). The park contains five major ponds with 12 roughly equal sized islands (approximately 464 to 1 590 m^2 in size) covered by varying degrees of herbaceous ground cover and a tall overstorey (10–40 m) of native and exotic trees and shrubs.

Data collection

General observations on ibis were collected from 17 March 2003 onwards, while conducting another study (Corben 2003). The first mating was observed on 30 May 2003, at which time eight ibis pairs were constructing nests. These and all other later erected nests were built on the islands. Formal data collection took place between 4 and 31 July 2003. Islands were visited once per week (total of five census days) and the number of nests, and eggs and nestlings per nest were recorded. Eggs were marked with a non-toxic, xylene-free felt pen to track and monitor individual nests and their contents. Twenty-seven nests, which were known to have contained eggs for at least three weeks, were used to calculate mean (± standard error (SE)) and modal clutch sizes. The young of 11 nests were monitored until fledging. Young were classified as fledglings when they were (1) over three weeks old and had joined a crèche, or (2) capable of flight. The nest origin of crèche-aged young was determined by: (1) comparing data on hatchlings, nestling ages and nest origins of young; and (2) observing the behaviour of both young and adults. In particular, we recorded: (a) which nests the young visited or left; (b) which nests the adults attended; and (c) which and how many juveniles the adults fed. These observations were made throughout the day twice weekly (total of ten observation days). Once we were certain that we had determined the nest origin correctly, based on a long series of consistent observations, we used these data to calculate the mean (± SE) and modal fledgling success per successful (nestlings hatched) nest.

Although complete fledging occurs between four and five weeks of age, it became harder to individually track mobile young and their origins once they had joined a crèche. Lowe (1984) and Beilharz (1988) defined fledglings as young that had left the nest and were over four weeks old, although Lowe (1984) did include three-week-old young at some sites. Including three week old young could overestimate fledgling success, however very few deaths occur after the chicks were three weeks old and less than 2.5 per cent of all failures happen in the fourth week of brooding (Beilharz 1988). Furthermore, no deaths of crèche-aged young were observed during the study. Therefore, it is considered that including three-week-old young in our study will not significantly overestimate fledgling success, rendering our results comparable to those reported in the literature.

RESULTS

The total number of nests in the colony at Centennial Park increased throughout the study from 180 active nests (4 July 2003) to an overall peak of 249 active nests on 31 July 2003. Water levels of the ponds fluctuated during the study and at times some islands were connected to the shore. Nests were built only on islands that always remained completely surrounded by water. Nests were primarily erected on vegetation less than one metre tall. However, by 31 July space on lower vegetation had become scarce and the birds began to construct nests directly on the ground. Twenty-seven nests were tracked until they reached their final clutch size. Ibis laid clutches between one and four eggs (Fig. 1) with a mean clutch size of 2.70 (± 0.13 SE) and a modal clutch size of three. Two nests (7.4%) contained the maximum observed clutch size of four eggs (Fig. 1).

Eleven nests were monitored until the young fledged. Ibis pairs successfully raised between one and four chicks to the fledgling stage (Fig. 2). The mean number of fledglings per nest was 2.64 (± 0.24 SE). The modal number of fledglings per nest was three with six nests (54.5%)

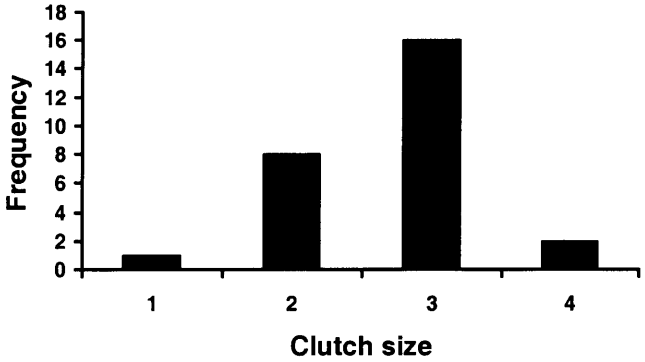

Figure 1. *Clutch sizes of 27 ibis nests in Centennial Park during July 2003. Clutches contained between one and four eggs. Bars indicate the frequencies of each clutch size.*

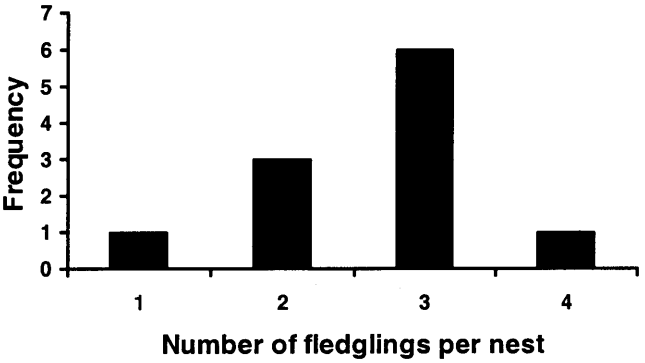

Figure 2. *Number of fledglings per nest in Centennial Park during July 2003. Nests (n = 11) produced between one and four fledglings.*

fledging three and one nest (9.1%) fledging four young (Fig. 2). None of the monitored fledglings died during the study.

DISCUSSION

The mean (2.70 ± 0.13 SE) and modal clutch size (3) of ibis in Sydney's Centennial Park is consistent with that reported for non-urban ibis in the literature. Both Lowe (1984) and Beilharz (1988) reported modal clutch sizes of three with annual mean clutch sizes between 2.60 and 2.88 at Healesville Sanctuary, Victoria. In general, Lowe (1984) found that coastal ibis colonies had smaller mean clutch sizes (2.52 to 2.82) than those from inland ibis colonies (2.98 to 3.21). The results of our study are therefore consistent with those expected for a coastal colony, and suggest that ibis from urban environments have similar clutch sizes to those breeding in more natural environments. This suggests that the increase in urban ibis populations throughout eastern Australia is not the result of urban ibis laying larger clutches.

However, the mean (2.64 ± 0.24 SE) and modal number of fledglings (3) raised per nest in Centennial Park is considerably higher than those described elsewhere. Beilharz (1988) reports a mean number of 1.73 (± 0.02 se) (modal number = 2) of young fledged per successful nest for Healesville Sanctuary (see also Marchant and Higgins 1990). Although 70 per cent of clutches in Beilharz's (1988) study contained three eggs, the number of broods that fledged three young was less than 7 per cent. Only one of 990 successful nests fledged four young. Similarly, Lowe (1984) found a maximum mean fledgling success of 1.29 young at Healesville Sanctuary. Only 5 to 15 per cent of active nests fledged three young and no ibis ever fledged more than three young. Lowe (1984) also added an extra egg to clutches of three and monitored their success rate. However, none of these nests fledged four young. In comparison, we found seven (63.6%) of 11 nests fledging at least three young. This suggests that the breeding colony of Centennial Park, and possibly other urban colonies, have a higher fledging success than Healesville Sanctuary and other coastal and inland colonies (Lowe 1984; Beilharz 1988).

Both Lowe (1984) and Beilharz (1988) concluded that food supply was the major factor limiting breeding success. Beilharz (1988) found that brood reduction occurred after hatching through starvation, which mainly affected the third and later hatching chicks. Ibis hatch asynchronously, approximately two to three days apart (Beilharz 1988). Although Beilharz (1983) found no feeding bias of parental ibis toward their young, the youngest of three chicks would be fed significantly less than its older siblings due to their younger age and inferior begging ability (Beilharz 1988). Hence, the survival of a fourth and fifth chick would be even less likely, when food is limited. Lowe's studies (1984) at Healesville Sanctuary support these findings. He reported breeding success rates for this site, which are almost twice as high as those obtained from other sites. The most likely factor for the high breeding success appears to be the high food availability at Healesville Sanctuary (Lowe 1984).

The high reproductive success in Centennial Park suggests that the urban environment offers ibis a rich and reliable food source. In urban areas, ibis are highly successful at exploiting artificial food sources from landfills, rubbish bins and humans' offerings (Lowe 1999; Ross 2004; Shaw and Murray 2004). Studies on the movements of the ibis population from Centennial Park during this study revealed that the birds travelled regularly and consistently into a south-westerly direction towards a landfill (Lucas Heights, approximately 22 km from Centennial Park) (Corben 2003), which is frequented by large numbers of ibis (D. Mulquin, pers. comm.). Landfills offer a stationary and reliable food source to ibis. In the Gold Coast region, Queensland, landfills appear to provide up to 78 per cent of the birds' primary food supply (Shaw 2001). Improving landfill management practices by reducing the accessibility of putrescible waste appears to be essential for ibis management programmes aiming to reduce ibis population sizes and limit breeding success.

While our results suggest that urban ibis have a greater breeding success (= number of fledglings per successful nest) than ibis from more natural environments, it is important that management does not become primarily focused on the breeding success of urban ibis. A study by Corben (2003) on the ibis colony in Centennial Park suggests that this population, and most likely all ibis populations in Sydney, consist of a sedentary, permanently present subpopulation, and a mobile, large subpopulation that is only present during the breeding season. This mobile subpopulation spends the non-breeding season outside Sydney, possibly inland New South Wales, and travels into the city for breeding. As yet it is not known why ibis travel into urban areas for breeding, while breeding and overall abundances in their traditional areas seem to decrease (G. Ross, pers. comm.). Possible factors include a decline in the quality of traditional breeding areas in inland Australia due to reduced and altered water flows (Kingsford and Thomas 1995; Kingsford and Johnson 1998; Kingsford 2000) and/or droughts combined with a greater and reliable food availability in urban environments (Corben 2003). When developing management plans for ibis, their movements and apparent decline in inland Australia need to be taken into account, so that the species is not harmed on a regional or even national scale. Until the ibis' broad scale movements are clarified, management programmes aiming to reduce breeding success must be responsible and ensure the breeding success of ibis remains at a sustainable level.

While our results on the reproductive parameters of ibis in an urban environment will aid in developing management plans for ibis, they are of small samples and only cover the start and the peak of the ibis' breeding season. Future research over the entire breeding period with individually marked nestlings is recommended, so that post-fledgling survivorship and movements can be monitored. In addition, studies on the diet and foraging success of adult and fledgling ibis in urban areas are required to gain knowledge on the relationship between food availability and breeding success.

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