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OBSERVATIONS ON A GREAT EGRET *Ardea alba* AND NANKEEN NIGHT HERON *Nycticorax caledonicus* COLONY AT THE PERTH ZOO, WESTERN AUSTRALIA

ROBYN L. PHILLIMORE[1] and HARRY F. RECHER[2]

[1]School of Natural Sciences, Edith Cowan University, Joondalup, Western Australia, Australia 6027
email: robynp@calm.wa.gov.au; hjrecher@pacific.net.au
[2]Corresponding author. Present address: P.O. Box 154, Brooklyn, New South Wales, Australia 2083

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A colony of Great Egrets *Ardea alba* and Nankeen Night Herons *Nycticorax caledonicus* has existed at the Perth Zoo, Western Australia for over 25 years. The colony of egrets is one of very few in the region and hence is significant for the conservation and management of Great Egrets in Western Australia. From 1996 to 1998, surveys were conducted to determine the number of breeding pairs, clutch size, breeding success, and nest site selection of birds in the colony. Most observations were ground based, but a 30-metre cherry picker was used to inspect nests and determine clutch size. One hundred and thirty night heron and 49 egret nests were found in 1996; 92 night heron and 41 egret nests in 1997; and, 153 night heron and 36 egret nests in 1998. Nesting commenced in September, with peak numbers in early November. Both species nested in tall trees well above zoo visitors and animals. Egrets nested only in pines, whereas night herons nested mainly in figs. Great Egrets had an average clutch size of 2.6–2.7 by early November compared with a clutch of 1.6–1.8 for Nankeen Night Herons. It was estimated that 95 per cent of egret eggs and 89 per cent of night heron eggs laid by early November in 1997 hatched and that 53 per cent of egret eggs (1.4 per nest) and 65 per cent of night heron eggs (1.2 per nest) survived to fledging. Incomplete data precluded estimates of breeding success for 1996 and 1998. The colony appears viable, but its long-term survival depends on the on-going provision of nest trees within the zoo and the conservation of foraging habitat within the Perth metropolitan area.

INTRODUCTION

In Western Australia, a colony of wild Great Egrets *Ardea alba* and Nankeen Night Herons *Nycticorax caledonicus* has existed at the Perth Zoo for over 25 years. The zoo colony is significant for the conservation and management of Great Egrets in Western Australia as it is the only colony of this species in the metropolitan area (Storey *et al.* 1993) and one of only nine colonies on the Swan Coastal Plain, between Moore River and Busselton (Jaensch and Vervest 1989), a distance of 300 kilometres. In contrast, Nankeen Night Herons are abundant throughout south-western Western Australia (Storr 1991) and nest elsewhere in Perth. Despite its conservation significance, there is limited information on the zoo colony, with only one published study, a count of nesting Great Egrets from 1986 to 1988 by Jaensch and Vervest (1989).

Although a feature of the zoo, the colony is under threat because of the aging and removal of nesting trees and the loss and degradation of estuarine and wetland foraging areas near Perth. Such threats may lead to the loss of the colony at Perth Zoo and a decrease in the presence of Great Egrets on the Swan Coastal Plain.

In this paper, we provide data on the number of breeding pairs, clutch size, breeding success, and nest site selection of egrets and night herons in the zoo colony. Some aspects of egret and night heron foraging ecology are also presented. These data establish a framework for the long-term monitoring of the colony. We use our observations to suggest some guidelines for the management and conservation of Great Egrets and Nankeen Night Herons at Perth Zoo.

METHODS

The Perth Zoo is situated in south Perth a few hundred metres from the Swan River estuary (32°02'S, 115°50'E). Surveys were conducted during the breeding season (September to December) in 1996, 1997 and 1998, to determine the number of nesting Great Egrets and Nankeen Night Herons.

In 1996, the aspect, height, and position within the nest trees of 39 Great Egret and 14 Nankeen Night Heron nests that were visible from the ground and unobstructed by foliage were measured and recorded. This sample consisted of egret nests in 28 pine trees and night heron nests in two fig trees. Aspect was recorded as north, south, east or west, with nests located between the cardinal points of the compass assigned as half a nest to each direction. The height of nests was measured using a clinometer. Nest position was recorded as either central (within the inner half of the crown) or peripheral (within the outer half of the crown), and the distance from the centre of the tree estimated. Height could be measured for only 29 of the 39 egret nests and we failed to record the aspect for one nest. All measurements were made on the 14 night heron nests.

Breeding biology

In the 1997 and 1998 breeding seasons, a 30-metre high cherry picker was used to count the number of eggs and chicks in a sample of nests. Nineteen pine trees with nesting egrets and 17 fig trees with nesting night herons were selected for study based on accessibility by the cherry picker. The pine trees were located in the Australian Bushwalk exhibit, while the fig trees were along Mill Point Road, a major road forming one boundary of the zoo. The difficulty in positioning and manoeuvring the cherry picker among trees precluded marking and monitoring individual nests.

Eggs and chicks were counted three times in 1997 (9 November, 23 November and 13 December) and again in 1998 (8 November, 22 November and 6 December). Clutch size was taken as the number of eggs and/or chicks found in each nest. It is possible that not all eggs laid were counted and that some eggs and chicks fell to the ground or were predated before counts commenced or between counts. Therefore, the counts from the cherry picker are a minimum estimate of clutch size. Only nests that contained eggs or chicks were considered active

and used to calculate minimum clutch size and survival rates. Estimates of clutch size were based on the contents of nests active on 9 November 1997 and 8 November 1998 when the number of active nests was greatest and chicks had not yet fledged. There was little evidence of prior mortality of either chicks or eggs.

Although egg laying started for both species in September, counts with the cherry picker did not commence until November to avoid disturbing the birds during laying. In 1997, counting was not attempted after 13 December when the chicks became mobile and could not be assigned to a nest. There was also the risk that young might be disturbed and fall. Nestlings could be counted from the ground once they had reached a size where their heads extended above the nest rim and ground surveys were used to monitor the progress of nestlings.

Breeding success

Breeding success was defined as the percentage of eggs laid that resulted in fledglings. It was estimated only for the group of nests monitored with the cherry picker in 1997. Data for 1996 and 1998 were incomplete and could not be used to estimate breeding success. In 1997, daily searches around the base of nest trees monitored with the cherry picker were made for fallen chicks and eggs as an estimate of mortality. Not all dead offspring were recorded, as some may have been removed by zoo staff and not reported, while others may have been taken by predators or eaten by zoo animals (some nests were above the Dingo *Canis familiaris dingo* enclosure). Hence, the number of fallen eggs and young is a minimum estimate of mortality. Broken egg shells that contained large amounts of yolk indicated the death of an embryo. Injured or abandoned chicks were counted as having died, although some were hand reared, banded and released. In the 1998 season, fallen chicks and eggs were counted on four days, 8 and 22 November, 6 December 1998 and 10 January 1999, as a check against the 1997 data.

Breeding success was estimated in the following way. The numbers of eggs and chicks found on the ground on or before 9 November were added to the count of eggs and nestlings made from the cherry picker on that day. Survival was then estimated by subtracting the total number of known dead eggs and chicks found during the daily ground searches from October to January from the number of eggs laid by 9 November. The average number of young produced per nest was estimated by dividing the number of young surviving until January by the number of known active nests.

Foraging behaviour

Egrets and night herons foraging within the zoo grounds were observed opportunistically and any prey caught or food eaten was recorded. These observations provided information on the extent to which Great Egrets and Nankeen Night Herons nesting at the zoo benefited from food provided to zoo animals. Prey found on the ground around the base of nest trees were collected and identified, but it was not always possible to assign these to either a night heron or an egret nest.

Data analysis

Statistical tests were performed using SPSS Statistical Package with a 5 per cent significance level. Nest heights were compared between species using a t-test. No statistical analyses were performed on nest aspect, position or distance from the trunk as nests were evenly placed around the nest trees and the two species nested in trees with very different structures (pines vs figs).

T-tests were used to test for differences between the number of offspring, eggs and chicks comparing the counts on 9 November 1997 and 8 November 1998 for each species. These dates were when the greatest number of eggs and nestlings were counted.

RESULTS

One hundred and thirty night heron and 49 egret nests were found in 1996; 92 night heron and 41 egret nests in 1997; and, 153 night heron and 36 egret nests in 1998. The decrease in the number of egrets nesting from 1996 to 1998 was associated with a decrease in annual rainfall, from 889 millimetres in 1996 to 653 millimetres in 1997 and 684 millimetres in 1998. However, the differences were confounded by site disturbance. Two pine trees containing five Great Egret nests and four Nankeen Night Heron nests were removed in 1997 to make room for new exhibits.

Nest site characteristics

All egret nests were located within the zoo grounds in Canary Island Pines *Pinus canariensis* in the Australian Bushwalk display, an area open to the public. Night herons nested in a variety of plants within the zoo grounds, including figs, pines, bamboo and eucalypts throughout the northern and eastern sections of the zoo. Most night heron nests were in figs and obscured by foliage and branches. All nest trees were introductions to Western Australia.

The average height of 29 egret nests was 21 metres (± 0.8 SE), with a range from 13 to 29 metres above the ground. Fourteen night heron nests averaged 19 metres (± 0.9 SE), and ranged from 12 to 26 metres above the ground. The height of nests did not differ ($df = 41$, $t = 1.63$, $P > 0.05$) between egrets and night herons. Of 39 egret nests, 33 were peripheral, with only six sited centrally. The mean distance of egret nests from the tree centre was 3.2 metres (± 0.4 SE). All 14 night heron nests measured were peripheral. This was where the foliage of figs was the densest. The mean distance of night heron nests from the tree center was 7.9 metres (± 0.6 SE). Nests of both species were placed evenly around the nest trees (Table 1).

TABLE 1

Aspect of Great Egret and Nankeen Night Heron nests that were visible from the ground and unobstructed by foliage at the Perth Zoo during 1996.

	Nest Aspect			
Species (n)	North	South	East	West
Great Egret (38)	10	8	10	10
Nankeen Night Heron (14)	2.5	4.5	3.5	3.5

Reproductive biology

Within the group of 19 pine trees selected for intensive study with the cherry picker, there were 33 active egret nests in 1997 and 32 in 1998 (Table 2). Within the 17 fig trees selected for intensive study, there were 23 active night heron nests in 1997 and 30 in 1998 (Table 2). Nesting by both species commenced in September.

Judging by the proportion of eggs to chicks, egrets and night herons commenced nesting and egg laying about the same time as each other in 1997 and 1998 (Table 2). However, the higher proportion of eggs to chicks on 8 November 1998 compared with the same time in 1997, and similarly between late November 1998 and early November 1997, suggest that nesting activity and egg laying by both species started as much as two weeks later in 1998 than 1997. Great Egrets had an average clutch size of 2.6–2.7 by early November compared with a clutch of 1.6–1.8 for Nankeen Night Herons (Table 2). There was no difference in clutch size between years for either egrets ($df = 58$, $t = 0.72$, $P > 0.05$) or night herons ($df = 51$, $t = 1.31$, $P > 0.05$).

TABLE 2

The number of active Great Egret and Nankeen Night Heron nests containing offspring (eggs and chicks), eggs and chicks in the Perth Zoo colony. Eggs and chicks were recorded in a group of 19 pine and 17 fig trees that could be observed closely from a 30-metre cherry picker during the 1997 and 1998 breeding seasons. The December 1998 count was abandoned due to the advanced stage of development of many of the chicks. Means are ± standard error.

	Total nest sampled	No. nests with eggs and/or chicks (% active)	Mean No. eggs and/or chicks/active nests	Total eggs	Total chicks
Great Egret					
9 November 1997	33	33 (100)	2.6 ± 0.1	43	41
23 November 1997	31	29 (94)	2.2 ± 0.1	13	52
13 December 1997	31	21 (68)	1.6 ± 0.2	3	31
8 November 1998	29	27 (93)	2.7 ± 0.2	56	15
22 November 1998	33	32 (97)	2.6 ± 0.1	45	39
Nankeen Night Heron					
9 November 1997	32	23 (72)	1.6 ± 0.1	19	17
23 November 1997	35	17 (49)	1.3 ± 0.1	3	19
13 December 1997	35	2 (6)	1.5 ± 0.5	0	3
8 November 1998	38	30 (79)	1.8 ± 0.1	39	16
22 November 1998	34	27 (79)	1.8 ± 0.1	19	14

Mortality

During daily searches between October 1997 and January 1998, 38 egret chicks and two eggs, and twelve night heron chicks and three eggs, were found dead at the base of nesting trees, in nests, and wedged in trees. In 1998/99, with only four searches, six egret chicks and five night heron chicks were found dead.

Breeding success

Eighty-four egret and 36 night heron eggs and chicks were counted from the cherry picker on 9 November 1997 (Table 2). Assuming all eggs were accounted for, 95 per cent of the egret eggs and 89 per cent of the night heron eggs present on or before 9 November 1997 hatched. A similar comparison for 1998 is not possible, as the count on 6 December 1998 was halted before completion. This was done because some chicks became agitated and fell (see Phillimore and Recher 1999). This count was not included in calculations. However, ground observations of nestlings at this time indicated that few eggs failed to hatch.

A number of eggs and chicks were found on the ground during 1997 before 9 November (one egret; seven night heron) and were added to the number of eggs and chicks in the nests monitored as an estimate of total production. It is also likely that some eggs or chicks were missed during counting and that some eggs were laid and lost before the first survey with the cherry picker or between counts. Nonetheless, the results suggest fledging success rates in 1997 of approximately 53 per cent (1.4 per nest) for egrets and 65 per cent (1.2 per nest) for night herons.

Zoo foraging

Although not observed taking food from zoo animals, Great Egrets took advantage of wild, live prey that was available on the zoo grounds, including tadpoles, frogs and Mosquito Fish *Gambusia holbrooki*. Night herons were observed stealing food from the Brolga *Grus rubicunda* cage on most days and from the Australian Bustard *Ardeotis australis* cage less frequently. They were also observed taking fish fed to Australian Pelicans *Pelecanus conspicillatus* at the zoo lake. This was a daily occurrence. Food items found at the base of nest trees included crab claws, Yellowtail Scad *Atule mate* and House Mice *Mus musculus*.

DISCUSSION

According to Maddock (2000), Great Egret colonies in Western Australia tend to be small, with 59 per cent having fewer than 50 nests. Colony size for Nankeen Night Herons in Western Australia has not been documented prior to this study. Between 1996 and 1998, the heronry at Perth Zoo had 125–200 breeding pairs (90–150 Nankeen Night Herons and 35–50 Great Egrets) and represents a significant presence of egrets and night herons in the Perth metropolitan area. The presence of the colony contributes to the experience of visiting the zoo during the heron nesting season. Retaining the zoo colony is therefore an important goal for wildlife conservation in the urban environment of Perth.

Population trends

Jaensch and Vervest (1989) suggested that Great Egrets were increasing in abundance in Western Australia. In their survey of the Perth Zoo colony, they recorded ten egret nests in 1986, five in 1987 and 20 in 1988 (Jaensch and Vervest 1989). Whether the greater number of nesting egrets we recorded a decade later is evidence of a trend in increasing abundance is unclear, as the methods and intensity of survey differed between the two studies.

The size of heronries in Australia is affected by rainfall, with fewer birds nesting in years of low rainfall (Jaensch and Vervest 1989; Maddock and Baxter 1991; Maddock 2000). The greatest number of nesting egrets we recorded at the zoo was in 1996, a year of average rainfall for Perth. Despite much lower annual rainfall in both 1997 and 1998, the differences in the number of nesting egrets were small. However, the construction of new exhibits and the removal of nest trees in 1997 may have affected the colony. If annual rainfall affected the number of nesting egrets, it seemingly had no effect on night herons, with the greatest

number of nests being recorded in 1998. Long-term annual counting of Great Egrets and Nankeen Night Herons at Perth Zoo is required to document population trends and reveal the relationships, if any, between the number of nesting birds, rainfall and management of the zoo grounds. However, the colony appears viable provided the zoo grounds are managed sympathetically and adequate nest trees are provided, and appropriate foraging habitat is maintained within the Perth region.

Nest site selection

Despite the large number of visitors and high levels of activity within nesting areas, the Perth Zoo provides a safe nesting area for egrets and night herons near extensive foraging habitat along the Swan River and in urban wetlands. Gibbs and Kinkel (1997) suggested that herons will nest in a variety of vegetation types as long as there is protection from disturbance, while Vos *et al.* (1985) concluded that herons habituate to repeated, non-threatening activities. Protection from disturbance is probably a significant factor in the selection of the zoo as a nesting area by Great Egrets in the Perth region.

Within the zoo, egrets selected tall pine trees while night herons selected both tall pine and fig trees in which to nest. These provided dense, sheltering and supporting vegetation well above the ground and away from zoo visitors and animals. The position of nests within these trees appeared to be determined by support for the nest and was unrelated to other environmental factors.

Season, clutch size and breeding success

In south-western Australia, Great Egrets nest from September to November, and Nankeen Night Herons from September to December, with clutch sizes of three to four for egrets and two to four for night herons (Johnstone and Storr 1998). At Perth Zoo Great Egrets and Nankeen Night Herons nested from September to December, but clutch sizes for egrets averaged less than three and less than two for night herons in both 1997 and 1998. Our data suggest that clutch sizes in the zoo colony may be lower than elsewhere in the south-west. The reasons for this are unclear.

Most nests at Perth Zoo succeeded in producing young. Our estimates indicate that both species averaged more than one fledgling per nest. More than 88 per cent of known eggs laid hatched and 53 per cent of egret eggs and 65 per cent of night heron eggs produced fledglings. As we observed no predation on nests, the major cause of mortality was chicks falling to the ground, although some eggs were also lost in this way. Butler (1997) and Ranglack *et al.* (1991) reported that a major cause of chick mortality in heron colonies was the inability of chicks to return to their nest after falling out. There was no evidence at Perth Zoo of egret or night heron chicks dying of starvation.

Despite what appeared to be a relatively high success rate, the production of young was less than the average of 1.8 to 2.5 fledglings per nest reported for Great Egret nests in eastern Australia (Marchant and Higgins 1990; Maddock and Baxter 1991). Such differences, based on short-term studies, need to be interpreted cautiously. For example, Butler *et al.* (1995) found that the number of Great Blue Heron *Ardea herodias* nesting pairs in colonies and fledging success in British Colombia was highly variable between years. Studies that last only a few years and include few colonies might not be representative of overall fledging success within those colonies or regions. Further monitoring of nest success at Perth Zoo is required.

Management and conservation

The conservation of herons requires the provision of safe breeding sites and having quality feeding areas available (Kushlan 1997, 2000; Hafner 2000). The Perth Zoo is a safe breeding area for Great Egrets and Nankeen Night Herons and foraging habitat for both species occurs throughout the metropolitan area. However, there are no guarantees that either situation will persist in the long-term as the population of Perth expands and the zoo is re-developed. Water quality problems (e.g. industrial pollution, toxic algal blooms and oxygen deficits) are a feature of the Swan River and its tributaries, while urban expansion and the extraction of groundwater threaten urban wetlands.

Conservation of foraging habitat along the Swan River and on urban wetlands will depend on the success of initiatives to improve water quality in the catchment by limiting nutrient runoff and preventing the discharge of agricultural, residential and industrial wastes into waterways. Given the complexity of the economic, environmental and social demands on water, the long-term protection of heron and egret foraging habitat is far from assured.

The choice of tall trees for nesting suggests that long-term nesting opportunities by Great Egrets, and to a lesser extent Nankeen Night Herons, at the Perth Zoo may be limited. Expansion and construction of zoo exhibits has produced a gradual decline in the number of nest trees, and may already have resulted in a decline in the number of nesting Great Egrets. A strategy to 'ensure continual and permanent nesting sites for the Great Egret with ongoing plantings and necessary tree surgery of Canary Island Pine trees' (Crombie 2000, p. 15) has been included in the Perth Zoo Botanical Plan, so no further reduction in nesting habitat should occur, but a more proactive approach that recognizes the specific needs of the egrets nesting at the zoo may be required. Nankeen Night Herons are more flexible in their choice of nesting trees and do not appear to have been affected by any reductions in nesting habitat at the Perth Zoo, but the health and provision of fig trees for nesting needs to be closely monitored.

The role of zoos in the 21st Century is a subject of considerable interest and debate (Mazur 2001). Most zoo curators would probably agree that zoos have an important role in the conservation of global and regional biodiversity. A significant contribution to conservation is made by zoos through their programmes of education. As a feature of the Perth Zoo, the egret and night heron colony is ideally placed to promote a range of educational activities, including the importance of maintaining or improving water quality in the Swan River catchment and urban wetlands. We see both an opportunity and a need for the Perth Zoo to take a proactive educational role in water

management in the Perth region by using the zoo egret and night heron colony to explain the links between the water people use and the needs of wildlife.

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