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SEASONAL AND DIURNAL PATTERNS IN ABUNDANCE OF WATERBIRDS AT A WASTE STABILIZATION POND, VICTORIA

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Seasonal and diurnal patterns in abundance of waterbirds (excluding waterfowl: Anatidae) on a waste-stabilization pond (Pond Nine) within the Lake Borrie System at the Western Treatment Plant, Werribee, Victoria were determined. The Western Treatment Plant is an important Ramsar site, mainly for the waterbird populations that occur there. Pond Nine often supports large numbers of waterbirds. However, seasonal and diurnal use of the site has received little attention to date.

The pond was used as a non-breeding site by large numbers of Straw-necked Ibises and also by more variable numbers of Australian White Ibises, Pied Cormorants, Little Pied Cormorants, Little Black Cormorants, Australian Pelicans, Silver Gulls, Eurasian Coots and Hoary-headed Grebes.

Straw-necked Ibises, Australian White Ibises, Pied Cormorants, Little Pied Cormorants, Little Black Cormorants, Silver Gulls and Australian Pelicans demonstrated crepuscular peaks of abundance. None of these species feed regularly at Pond Nine. In contrast, species that fed at or near Pond Nine, such as Eurasian Coot, Hoary-headed Grebe and consistent numbers of Black-winged Stilts were observed throughout the day.

INTRODUCTION

The migration patterns of waterbirds are often studied by monitoring the movements of individually marked birds. This method has the advantage of providing direct evidence of movements but is often limited by small sample sizes. Changes in the abundance of populations at particular sites can also be used to determine seasonal movements and, whilst such data do not provide direct evidence of movements, they can be used in conjunction with banding data to develop a more complete picture.

This paper presents information on seasonal abundance patterns of waterbirds at the Western Treatment Plant (WTP) on the Victorian coast. It is only concerned with waterbird species that do not belong to the family Anatidae (waterfowl). Waterfowl were considered separately by Hamilton *et al.* 2002. The data are used to make inferences on seasonal movements and also to infer the significance of the WTP in the annual life cycles of the birds. The WTP is known to be an important site for waterbirds. It is of regional or state significance for several species, including the Hoary-headed Grebe *Poliocephalus poliocephalus* (state), Straw-necked Ibis *Threskiornis spinicollis* (state), Little Black Cormorant *Phalacrocorax sulcirostris* (regional and possibly state) and Pied Cormorant *Phalacrocorax varius* (state) (Lane and Peake 1990). There is little information on seasonal changes in abundance for these species at the WTP. Elliget (1980) presented data for a few species from March to October in 1980 and Steele (1996) summarized data for Eurasian Coots *Fulica atra* and Hoary-headed Grebes.

Daily movements to and from roosts have not been well studied for many Australian waterbirds. Marchant and Higgins (1990) concluded that no systematic information on times of arrival and departure from roosts exists for the Australian Pelican *Pelecanus conspicillatus*, Great Cormorant *Phalacrocorax carbo*, Little Black Cormorant, or Little Pied Cormorant *Phalacrocorax melanoleucos*. Here we describe diurnal changes in abundance of waterbirds at Pond Nine.

MATERIALS AND METHODS

Study site

The Western Treatment Plant occupies an area of 10 851 hectares and is situated 35 kilometres south-west of Melbourne on the shores of Port Phillip Bay (38°00'S, 144°34'E) (Fig. 1). Observations for the present study were made at a waste stabilization pond known as Pond Nine, part of a series of ponds that make up the Lake Borrie system. Pond Nine, which covers 109 hectares, is the largest pond. It is also the only pond in the system with a stand of dead trees (mostly *Melaleuca lanceolata*) that can be used as roost sites. The average water depth is 60 centimetres (Cartwright, unpubl. data, 1996).

Sampling protocol

Sampling was undertaken on 47 dates: three times a month from 11 July 1998 to 20 June 1999 and then at approximately monthly intervals from 1 August 1999 to 9 August 2000. Sampling was conducted at five evenly spaced times of day: sunrise, mid-morning, midday, mid-afternoon and sunset. Typically, it took about one hour to sample the entire pond, hence sampling for each time of day started 30 minutes before the midpoint of the sampling period (e.g. 30 mins before sunrise).

Surveys were made from defined observation points on the embankment using a Leica® Televid 77 telescope (20–60 × zoom magnification). The pond was too large to be sampled from one point and it was divided into five sections.

Large numbers of Straw-necked Ibis and occasionally Australian White Ibis *Threskiornis molucca* in the trees, and Hoary-headed Grebe on the water, were estimated groups of 100 or 1 000, depending on flock size.

Hoary-headed Grebe was the only species that regularly dived at Pond Nine (Eurasian Coot, generally considered a partial diving species, was rarely seen diving at Pond Nine). For this species a preliminary study

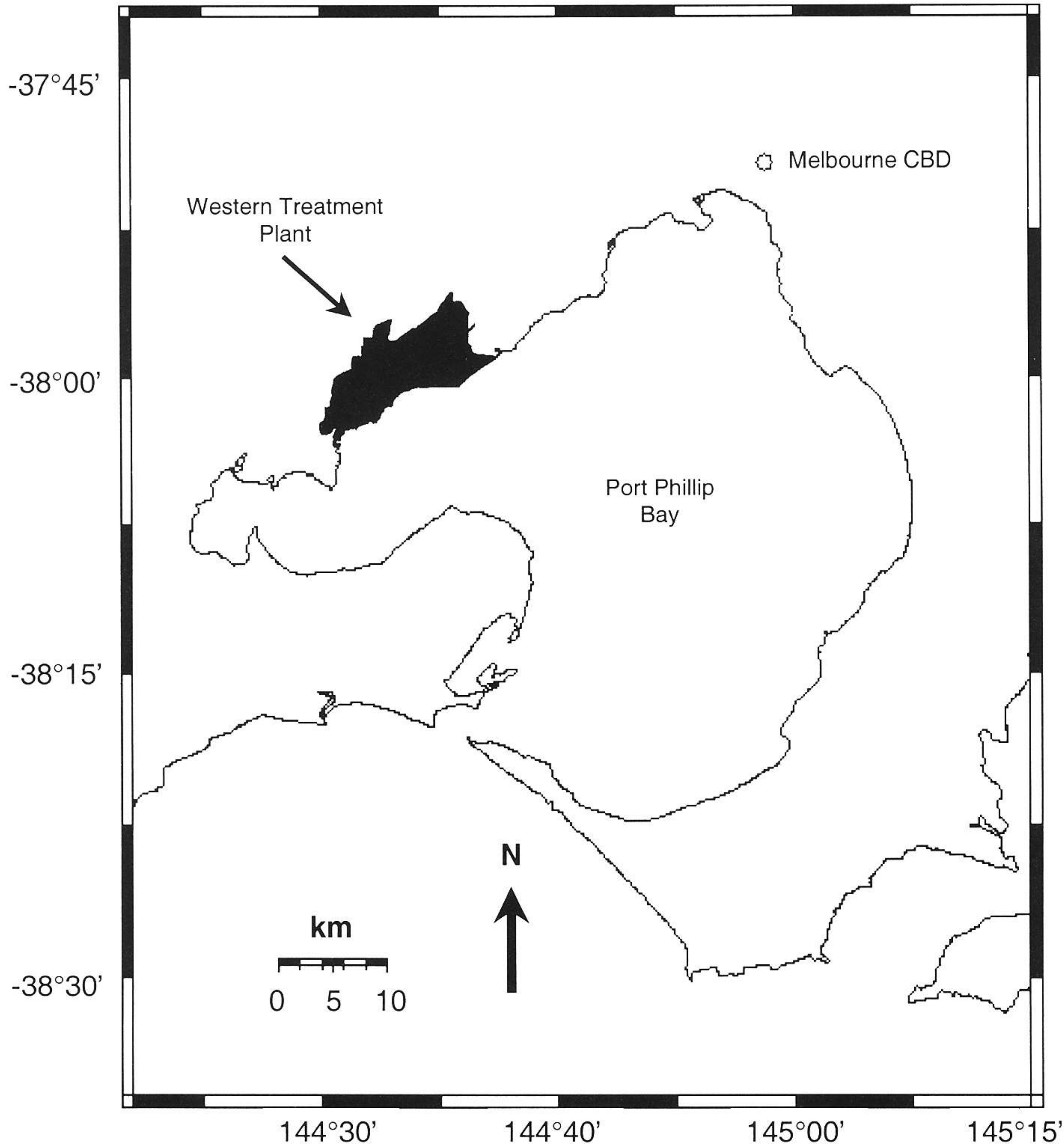

Figure 1. *Map showing the location of the Western Treatment Plant.*

was undertaken to determine the maximum dive length. The maximum dive length was found to be 20 seconds (mean = 12.5 s, s.e. = 0.75 s), and hence in the surveys each field of view was maintained for at least 20 seconds to enable any birds below the surface enough time to resurface and be counted. Barlow (1976) and Best (1976) identified similar dive lengths for this species.

Night-time observations

Night vision equipment — Fujinon® PS-910 Starscope (1 × magnification) — was only available for one night during the study (25 October 1999). Observations were made at three times: 'evening' (midway between sunset and midnight), 'midnight' (midway between sunrise and sunset), and 'early morning' (midway between midnight and sunrise). Even with the aid of night-vision apparatus, most species were too small and too far away to be identified clearly; hence observations are only presented for the two species that could clearly be identified, Australian Pelican and Pied Cormorant.

Data Analysis

Several species showed strong diurnal trends in abundance and for this reason both daily maxima and mean values were plotted when representing seasonal abundance trends. Daily maximum values are particularly meaningful for species that show diurnal trends in abundance since a site could still have been important to a species at a particular time of year even if it was only used at certain times of day. Seasonal abundance data were only plotted for species where at least five individuals (for any time of day) were observed on a minimum of ten dates throughout the study.

The abundance and frequency of occurrence of species varied substantially, from those species often seen in the thousands (e.g. Straw-necked Ibis) to species where only one bird was recorded throughout the entire study (i.e. Great Crested Grebe *Podiceps cristatus*). Only the more common species satisfying an arbitrary criterion of at least 50 individuals for the entire day on a minimum of five dates were included in the analysis. The effect of time of day on abundance was analysed using analysis of variance with date being modelled as a blocking factor. A complete census was made of each section, so data could be pooled across sections. Data were $\log_{10}(x + 1)$ transformed for each species to improve homoscedasticity; the transformation also improved normality of data for each species. All analyses were performed using GenStat for Windows, 5th Edition (Lawes Agricultural Trust, IACR-Rothamsted). All comparisons between means were made at the P = 0.05 level.

RESULTS

Seasonal abundance

Straw-necked Ibis abundance peaked in mid-autumn in both 1999 and 2000, although relatively high numbers were also observed in the 1998 winter (Fig. 2). Australian White Ibis abundance followed a roughly similar trend to that of the Straw-necked Ibis, although there was no winter peak in 1998 (Fig. 3). Pied Cormorant numbers were generally highest in spring each year (Fig. 4), but patterns for all the other cormorant species were far more variable. Little Pied Cormorant numbers (Fig. 5) peaked on a few dates from late summer to late autumn in 1999 and on one date in autumn 2000. Little Black Cormorant and Australian Pelican numbers were erratic, with no obvious seasonal patterns (Figs 6, 7). Numbers of Silver Gulls *Larus novaehollandiae* and Purple Swamphens *Porphyrio porphyrio* tended to increase in autumn in both years (Figs 8, 11). Eurasian Coot abundance peaked in autumn 2000 but numbers were relatively consistent throughout 1999, following low levels from July through to December 1998 (Fig. 9). Hoary-headed Grebe numbers showed no consistent seasonal trends; peaks in the late winter 1998 and autumn 1999 were not repeated the following year (Fig. 10).

Diurnal abundance

There was a significant effect of time of day on abundance ($P < 0.05$) for all species except Eurasian Coot.

Both ibis species, all cormorant species, Australian Pelican and Silver Gull all demonstrated distinct peaks in abundance for the sunrise and sunset samples (Figs 12a, b, c, d, e, f, g). The peak abundance at sunset occurred for both Straw-necked Ibis and Silver Gull by the arrival of large flocks of birds from about 20 minutes before sunset up until sunset. Straw-necked Ibises mostly arrived from the north, from farmland, and the Silver Gulls from the south-east, from the coast. Straw-necked Ibis flocks were sometimes in the order of 5 000–7 000 birds. In contrast, Pied Cormorant and Australian Pelican numbers tended to build up gradually throughout the afternoon. For both species the mid-afternoon abundance was about 30 per cent of the sunset level (Figs 12c, f), compared to only 0.4 per cent and 2.3 per cent for Straw-necked Ibis and Silver Gull respectively. Little Pied Cormorant, Little Black

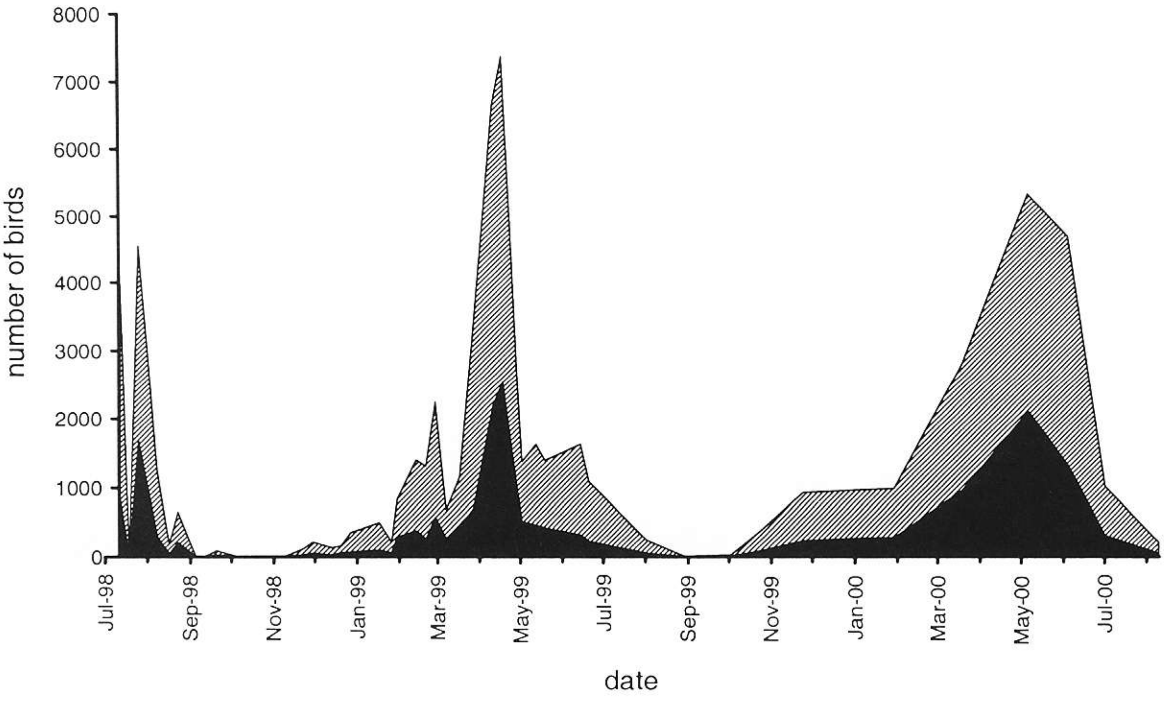

Figure 2. *Seasonal abundance of Straw-necked Ibis at Pond Nine. Dark shading represents daily mean abundance, striped shading represents daily maximum abundance. Labels on 'x' axis denote the first day of the month. The first sample date is in line with the 'y' axis and the last is at the end of the 'x' axis.*

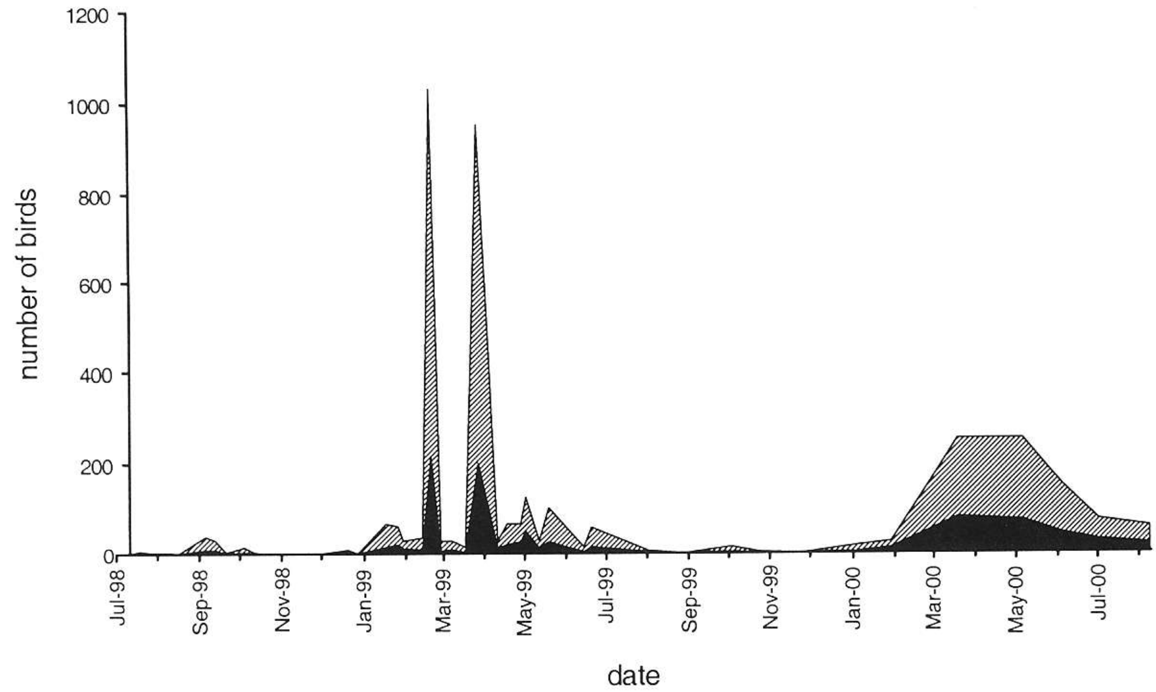

Figure 3. *Seasonal abundance of Australian White Ibis at Pond Nine. Dark shading represents daily mean abundance, striped shading represents daily maximum abundance. Labels on 'x' axis denote the first day of the month. The first sample date is in line with the 'y' axis and the last is at the end of the 'x' axis.*

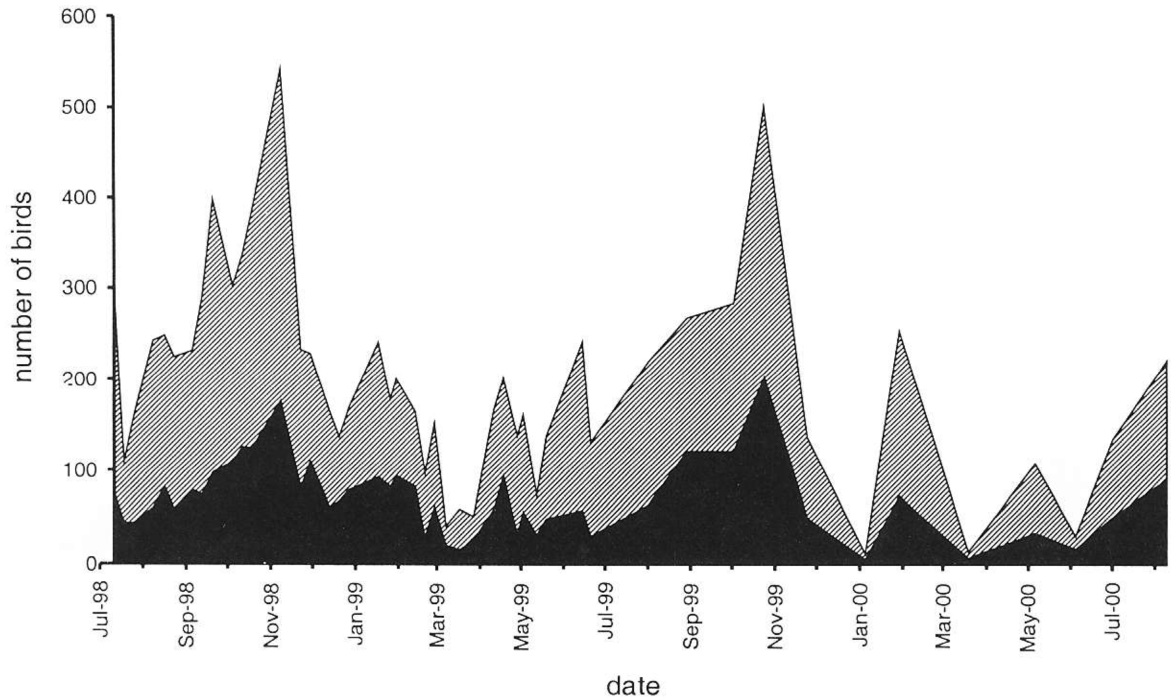

Figure 4. *Seasonal abundance of Pied Cormorant at Pond Nine. Dark shading represents daily mean abundance, striped shading represents daily maximum abundance. Labels on 'x' axis denote the first day of the month. The first sample date is in line with the 'y' axis and the last is at the end of the 'x' axis.*

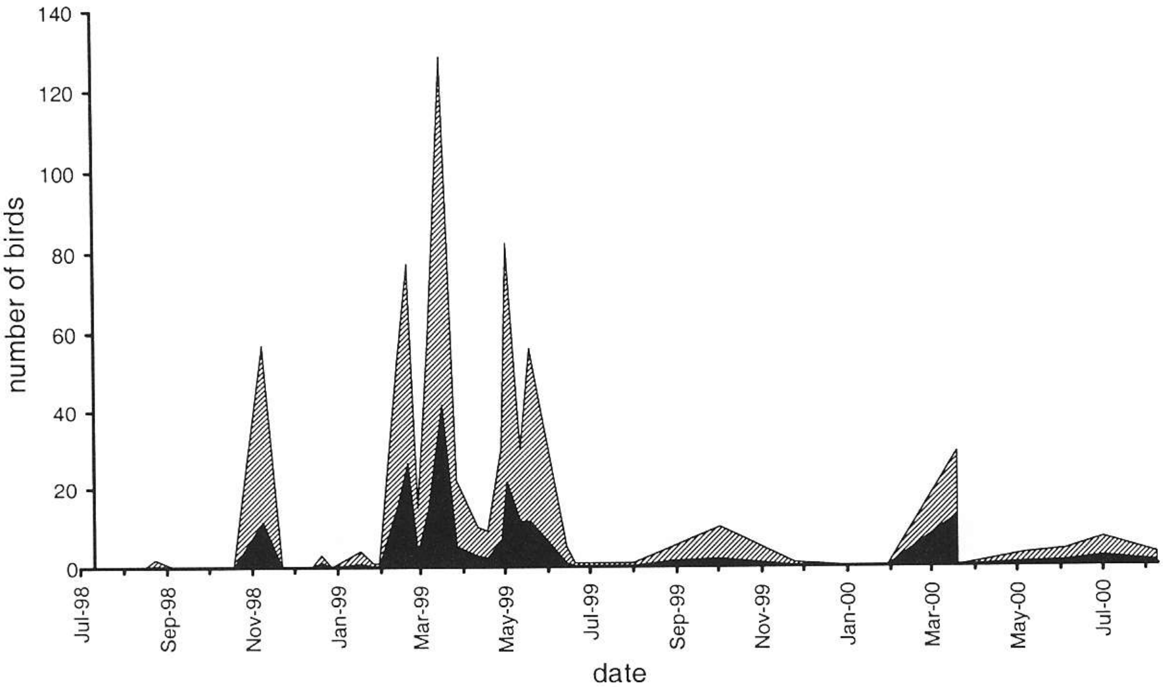

Figure 5. *Seasonal abundance of Little Pied Cormorant at Pond Nine. Dark shading represents daily mean abundance, striped shading represents daily maximum abundance. Labels on 'x' axis denote the first day of the month. The first sample date is in line with the 'y' axis and the last is at the end of the 'x' axis.*

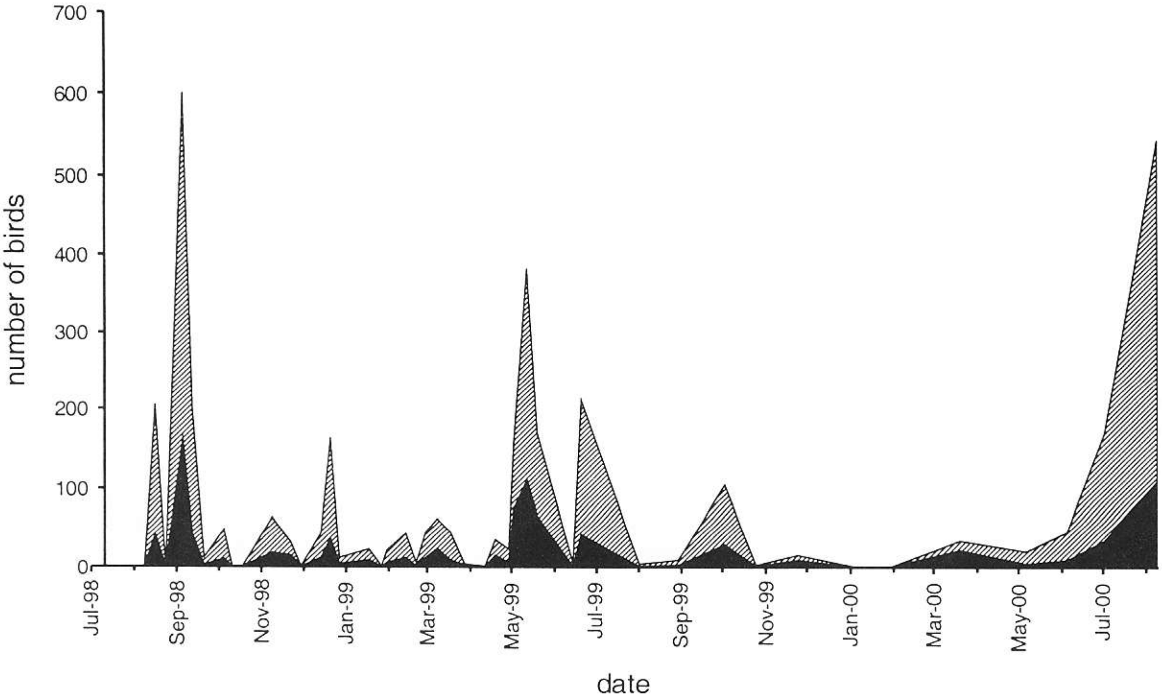

Figure 6. *Seasonal abundance of Little Black Cormorant at Pond Nine. Dark shading represents daily mean abundance, striped shading represents daily maximum abundance. Labels on 'x' axis denote the first day of the month. The first sample date is in line with the 'y' axis and the last is at the end of the 'x' axis.*

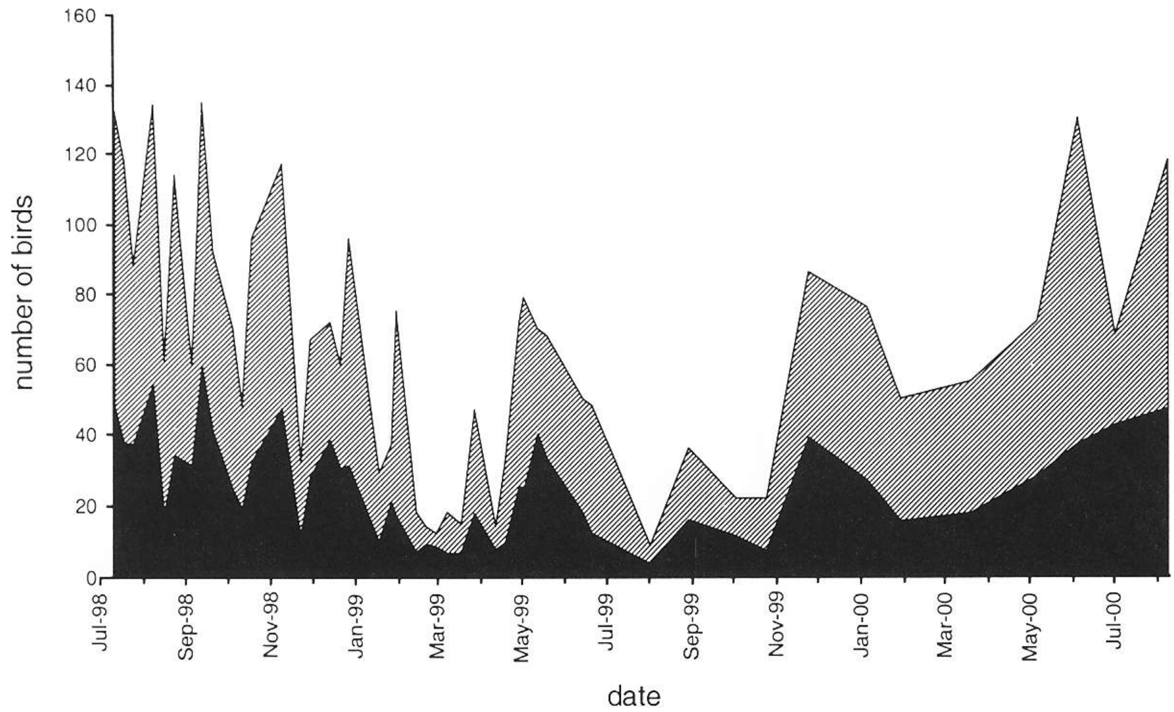

Figure 7. *Seasonal abundance of Australian Pelican at Pond Nine. Dark shading represents daily mean abundance, striped shading represents daily maximum abundance. Labels on 'x' axis denote the first day of the month. The first sample date is in line with the 'y' axis and the last is at the end of the 'x' axis.*

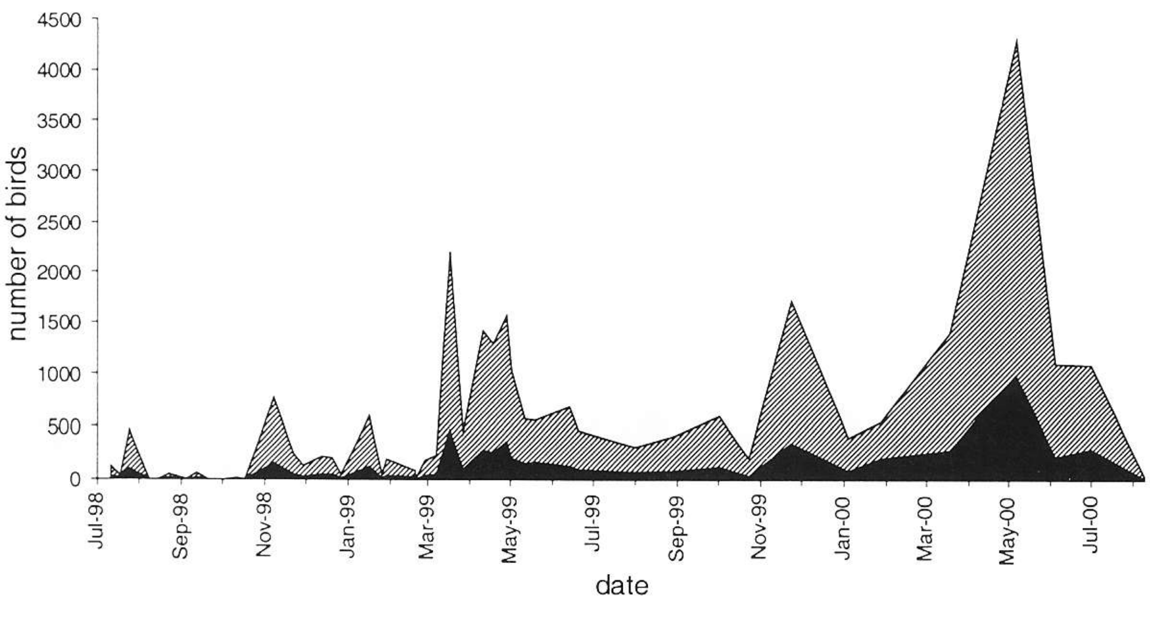

Figure 8. *Seasonal abundance of Silver Gull at Pond Nine. Dark shading represents daily mean abundance, striped shading represents daily maximum abundance. Labels on 'x' axis denote the first day of the month. The first sample date is in line with the 'y' axis and the last is at the end of the 'x' axis.*

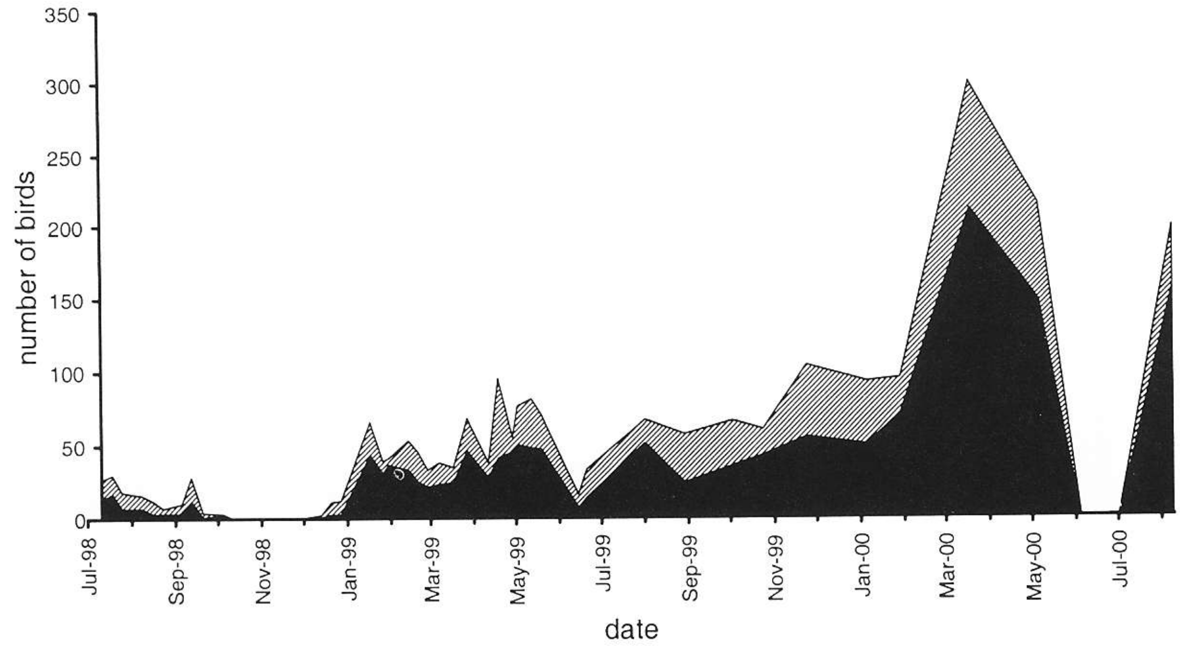

Figure 9. *Seasonal abundance of Eurasian Coot at Pond Nine. Dark shading represents daily mean abundance, striped shading represents daily maximum abundance. Labels on 'x' axis denote the first day of the month. The first sample date is in line with the 'y' axis and the last is at the end of the 'x' axis.*

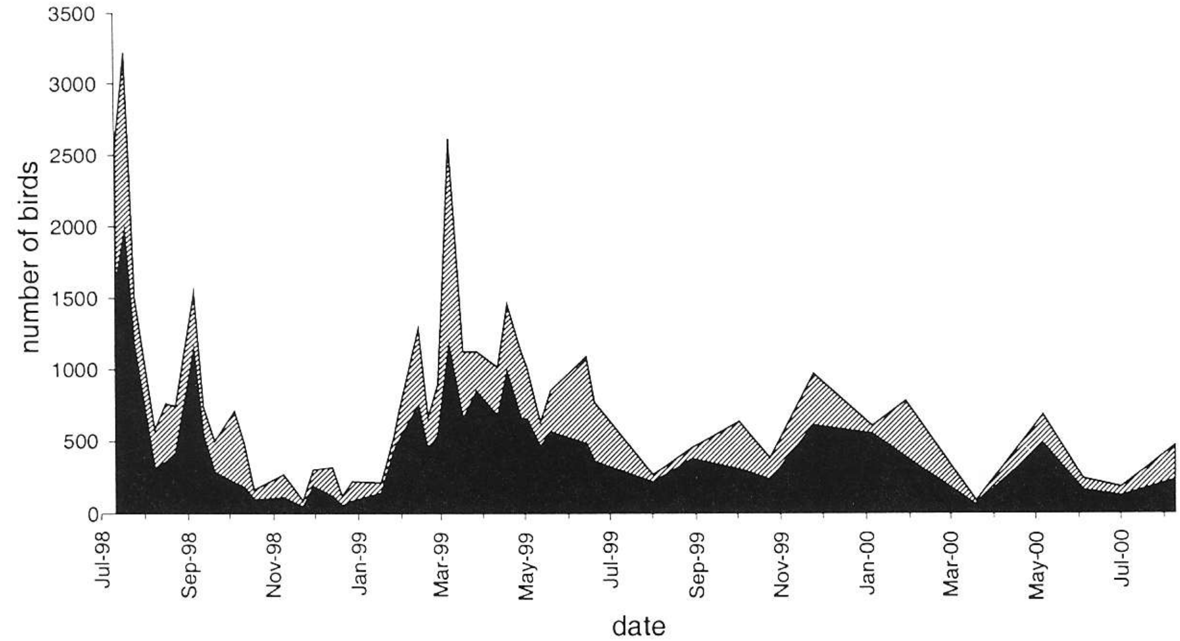

Figure 10. *Seasonal abundance of Hoary-headed Grebe at Pond Nine. Dark shading represents daily mean abundance, striped shading represents daily maximum abundance. Labels on 'x' axis denote the first day of the month. The first sample date is in line with the 'y' axis and the last is at the end of the 'x' axis.*

Cormorant and Australian White Ibis were roughly intermediate between these extremes, with the mid-afternoon numbers being 16.7 per cent, 22.7 per cent and 12.8 per cent (respectively) of those for sunset (Figs 12d, e, b).

Of the species that showed distinct crepuscular trends in abundance, several including both ibis species, Pied Cormorant, Australian Pelican and Silver Gull, were significantly more numerous at sunset than they were at sunrise (Figs 12a, b, c, f, g). This implies that many birds left the roost before the sunrise sample. Qualitative observations of both ibis species and Australian Pelican suggested that many birds left the roost at around first light, well before the sunrise sample was taken (i.e. > 45 mins before sunrise). Moreover, during the night time study, Australian Pelican and Pied Cormorant were present in the trees at the evening sample (7 and 95 respectively) but none of either species was seen at midnight. Australian Pelican numbers had increased again to four by early-morning, but Pied Cormorants were still absent.

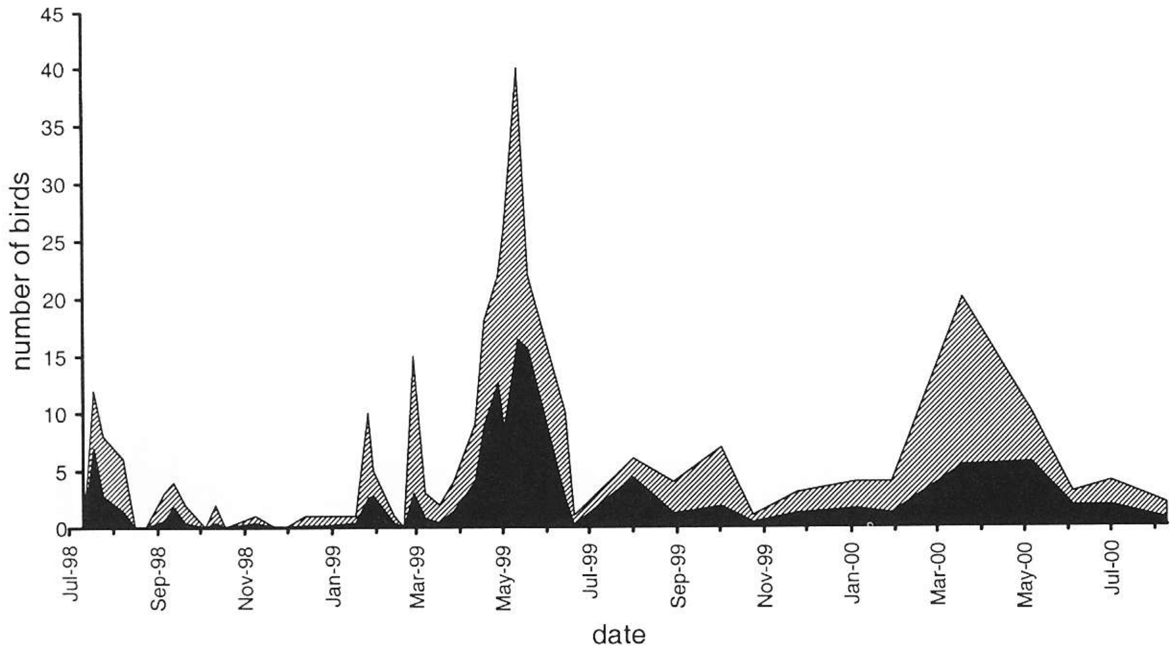

Figure 11. *Seasonal abundance of Purple Swamphen at Pond Nine. Dark shading represents daily mean abundance, striped shading represents daily maximum abundance. Labels on 'x' axis denote the first day of the month. The first sample date is in line with the 'y' axis and the last is at the end of the 'x' axis.*

TABLE 1

List of less common waterbird species observed at Pond Nine. Maximum abundance values represent the maximum number of birds seen on any particular date at any particular time of day. Minimum refers to the minimum number of birds (other than zero) observed. For species that were observed on only one occasion, the number of birds seen is presented in the maximum column only. Similarly, for species that were seen on more than one occasion, but for which the same number of birds were seen on each of these occasions, a value is only presented in the maximum column. The number of dates that a species was observed on is also presented.

	Minimum	Maximum	No. dates
Darter (*Anhinga melanogaster*)	1	4	1
Great Crested Grebe (*Podiceps cristatus*)		1	1
Dusky Moorhen (*Gallinula tenebrosa*)		1	1
White-faced Heron (*Egretta novaehollandiae*)	1	2	7
Cattle Egret (*Ardea ibis*)	1	80	12
Great Egret (*Ardea alba*)	1	3	3
Intermediate Egret (*Ardea intermedia*)	1	2	6
Australasian Bittern (*Botaurus poiciloptilus*)		1	2
Glossy Ibis (*Plegadis falcinellus*)	1	8	3
Royal Spoonbill (*Platalea regia*)	1	12	28
Yellow-billed Spoonbill (*Platalea flavipes*)	1	2	2
Marsh Sandpiper (*Tringa stagnatilis*)		1	2
Sharp-tailed Sandpiper (*Calidris acuminata*)	1	100	15
Red-necked Stint (*Calidris ruficollis*)	1	100	6
Masked Lapwing (*Vanellus miles*)	1	10	4
Red-kneed Dotterel (*Erythrogonys cinctus*)	1	5	9
Red-necked Avocet (*Recurvirostra novaehollandiae*)	1	250	8
Pacific Gull (*Larus pacificus*)	1	2	7
White-winged Black Tern (*Chlidonias leucopterus*)	7	81	2
Little Tern (*Sterna albifrons*)		1	1
Fairy Tern (*Sterna nereis*)		1	1
Crested Tern (*Sterna bergii*)		1	1

For Hoary-headed Grebe there were significantly more birds at sunset than at any other time of day except sunrise, but there were no significant differences in numbers between any other times of day (Fig. 12i).

Numbers of Eurasian Coot were consistent throughout the day with no significant differences between any two particular times of day (Fig. 12h). Black-winged Stilts *Himantopus himantopus* tended to use Pond Nine most frequently in the first half of the day (Fig. 12j).

Aside from the species mentioned thus far, several other less abundant waterbird species were observed at Pond Nine (Table 1). These 'less common' species did not satisfy the arbitrary criteria for seasonal and diurnal analysis described in the methods.

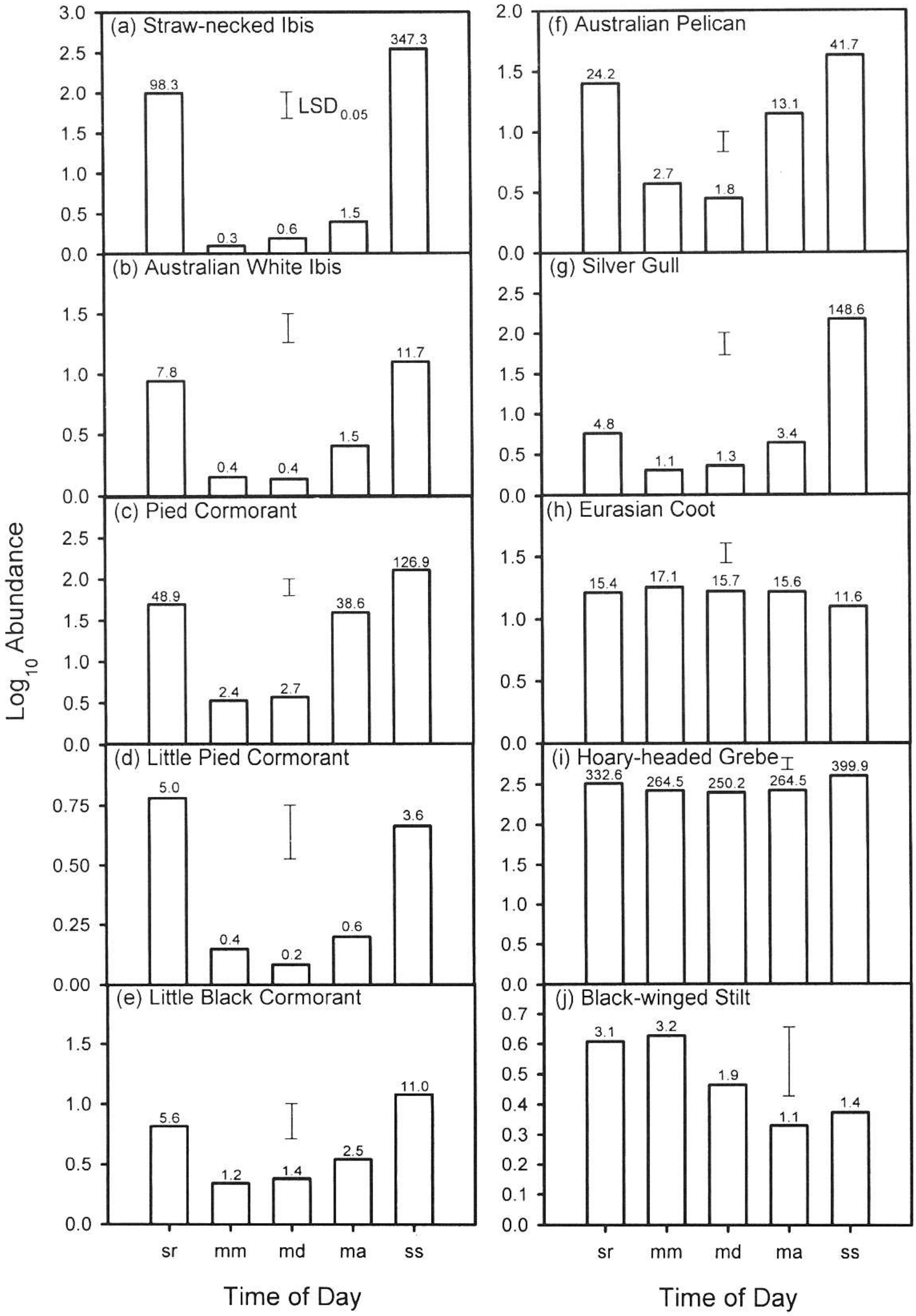

Figure 12. *Diurnal changes in abundance (log_{10} (x + 1)) of waterbirds at Pond Nine. sr = sunrise, mm = mid-morning, md = midday, ma = midafternoon, ss = sunset. Note that the effect of time of day was significant for all species ($P < 0.05$) except Eurasian Coot. Numbers above bars represent back-transformed means.*

DISCUSSION

Seasonal use of Pond Nine

Several species of waterbirds used Pond Nine during the apparent non-breeding season. In the species accounts below, seasonal variation in numbers is primarily discussed in relation to possible movements associated with breeding seasons. However, it is acknowledged that other factors, such as the condition of feeding sites or erratic inland rainfall events, might also be important for determining seasonal movements.

Straw-necked Ibises breed mostly in northern or south-eastern Australia. For those breeding in the north, north-eastern Queensland appears to be a non-breeding area, while for those breeding in the south-east, south-eastern Queensland is believed to be used in the non-breeding season (Carrick 1962; McKilligan 1975; Marchant and Higgins 1990). However, it has also been suggested that some birds are sedentary around breeding sites (Marchant and Higgins 1990). In the present study, large flocks were observed at Pond Nine after the southern breeding season of August to December (McKilligan 1975) each year. This suggests that after breeding in the south-east, many birds may move to Pond Nine, a non-breeding site, rather than move north or stay around their breeding sites. The autumn flocks at Pond Nine were often large (Fig. 2), and hence the site may be considered to be an important non-breeding resource for the species. In addition to the safe roosting habitat offered by the dead trees, the surrounding cattle pasture may add to the attractiveness of the site. Much of this pasture is flooded with sewage each summer as part of the land-filtration treatment system and is probably fertile and likely to support high invertebrate densities. Large flocks of Straw-necked Ibis were frequently seen feeding in these pastures.

Australian White Ibises also breed in spring and early summer (Marchant and Higgins 1990), and like the Straw-necked Ibis, they demonstrated peak abundance at Pond Nine shortly after this breeding period. Banding studies by Lowe (1984 — cited in Marchant and Higgins 1990) and analysis by Marchant and Higgins (1990) of the Australian Bird Atlas (Blakers *et al.* 1984) data suggest that, in contrast to the Straw-necked Ibis, this species remains in south-eastern Australia throughout the year. Thus, it is possible that some birds breeding in other parts of south-eastern Australia may use Pond Nine as a non-breeding site, although not in such high numbers as the Straw-necked Ibis. Australian White Ibises were also seen feeding in the surrounding land-filtration pastures during the day.

The Pied Cormorants reached peak abundance in spring each year. The only breeding data available for this species in south-eastern Australia comes from a three year study at Pond Nine itself in the early 1970s (Norman 1974), when it used to breed there in high numbers. Laying started at the end of May and had finished by the start of November, and hatching was complete by the start of December. In the present study numbers increased throughout winter and reached a peak around the end of spring each year. However, no nests were sighted at Pond Nine throughout the two year study.

No overall seasonal trends in abundance for Little Pied Cormorants have been reported in Victoria as a whole (Marchant and Higgins 1990), although Missen and Timms (1974) reported peaks in autumn and winter in western Victoria. In the present study, peak abundances were recorded from late-summer to the end of autumn in the first year (Fig. 5). In the second year, only an autumn peak was observed, although sampling frequency was less then. The timing of breeding in this species is not well understood. It has been suggested that like the Little Black Cormorant, it breeds mainly in spring and summer in the south, but it may also breed all year round (Marchant and Higgins 1990). Therefore, it is possible that the peak in abundance in late-summer/autumn 1999, and maybe even the single peak in March 2000, represent an influx of birds after breeding.

Marchant and Higgins (1990) have suggested that there is a general influx of Little Black Cormorants into Victoria in spring and summer. This was based on an analysis of data documented in the Victorian Bird Atlas (Emison *et al.* 1987). Little Black Cormorants are believed to breed in southern Australia in spring and summer, although evidence supporting this is generally anecdotal and they may apparently breed at any time of year (Marchant and Higgins 1990). There were no clear seasonal trends in abundance in the present study.

Australian Pelicans generally breed throughout the year, and according to reporting rates in the Victorian Bird Atlas (Emison *et al.* 1987), there are no regular seasonal movements; breeding and movements seem to be driven by environmental factors such as rainfall (Marchant and Higgins 1990). Abundance data from over the two years of this study (Fig. 7) tend to suggest that Pond Nine is used throughout the year as a regular roosting site. No nests were observed.

Silver Gull abundance was erratic, although there was a general tendency towards peak abundances in autumn each year, after the acknowledged spring/summer breeding season for south-eastern and eastern Australia (Marchant and Higgins 1990). Hence, it is assumed that Pond Nine was predominantly used as a non-breeding site. Silver Gulls are generally considered to be partly sedentary and partly nomadic/migratory. There are no clear large-scale seasonal movements (Marchant and Higgins 1990). It is possible that birds arriving at Pond Nine in autumn have come from breeding grounds elsewhere in south-eastern Australia. Wheeler and Watson (1963) reported that most adult and young birds departed breeding grounds at Altona, Victoria (<50 km east of Pond Nine) in November. However, this colony is probably not used any more, and the main breeding colony is now at Mud Islands in Port Phillip Bay (P. Dann, pers. comm.; E. Walker, pers. comm.; R. Jessop, pers. comm.).

Eurasian Coot abundance peaked around February to May each year, after the Victorian breeding season from around August to January (Bedggood 1980). However, there was substantial variation between the first and second years of the study. Abundance during the breeding season in the second year was similar to that for the non-breeding season of the first year (Fig. 9). Other counts at Lake

Borrie also depict a general trend of peak abundance during late summer and early spring (Steele 1996). In contrast, Elliget (1980) observed relatively consistent abundance throughout the duration of her March to October study at Lake Borrie. Whilst this species does not appear to undertake large-scale seasonal movements, numbers at particular sites are known to fluctuate seasonally (Emison *et al.* 1987; Marchant and Higgins 1990), although reasonably consistent abundances have been reported in some areas throughout the year (Leach and Hines 1987).

Marchant and Higgins (1990) suggest that the breeding season of Hoary-headed Grebes extends from September to January. Numbers at Pond Nine fell towards the end of the 1998 winter and stayed low from October through to the end of January, before peaking again from February through to the end of April in 1999 (Fig. 10). This pattern possibly suggests an influx of birds arriving after breeding, but it was not repeated the following year. However, Steele (1996) also reported a general trend towards peak abundance at the end of summer or start of spring.

In Victoria, Purple Swamphens breed from mid-August to December (Bedggood 1970). Peak abundance was recorded in March to May each year at Pond Nine matching earlier observations by Elliget (1980). In New Zealand, they are not known to undertake large-scale seasonal migrations, and may stay in their territory throughout the year (Craig 1979, 1984). However, dispersal has been recorded, presumably in response to food availability (Norman and Mumford 1985). The peaks in abundance at Pond Nine after the breeding season may represent either recruitment of new birds through breeding at Pond Nine itself or an influx of birds from a breeding site elsewhere. The latter is more likely as no nests, broods or juveniles were seen at Pond Nine.

Diurnal abundance

Straw-necked Ibises and Australian White Ibises are generally considered to arrive at roosts just before sunset, and depart around sunrise, but this has not been quantified before (Marchant and Higgins 1990). This belief is supported to a degree by the findings of the current study, where numbers of both species were clearly greatest around sunrise and sunset. However, Australian White Ibises tended to arrive anytime from mid-afternoon through to sunset, whereas the large Straw-necked Ibis flocks generally arrived within the last 20 minutes before sunset.

Milliner (1972, cited in Marchant and Higgins 1990) found that the Pied Cormorants started to arrive at the roost around 2.5 hours before sunset (roughly equivalent to 'mid-afternoon' in present study) and the majority had arrived by half an hour before sunset. The present study also supports a gradual arrival of birds over the afternoon (Fig. 12c). In contrast, Stonehouse (1967), in a study of New Zealand shags, observed that most birds returned to the roost within the last hour before sunset and departed within the first and second hours after sunrise. However, observations from the present study suggest that many birds may leave the roost well before sunrise.

Daily use of roosts by Little Pied Cormorants and Little Black Cormorants has not been studied in depth. Potts (1977 — cited in Marchant and Higgins 1990) made the general observation that both these species depart from the roost at around sunrise, or just after, and arrive around sunset, or just before. Data from the present study tend to support these observations, with greatest numbers of birds being reported at sunrise and sunset. Furthermore, unlike the other species that demonstrated crepuscular peaks in abundance, there was no significant difference between numbers at sunrise and sunset for these two species, which suggests that they did not generally depart the roost before the sunrise sample.

No information exists for diurnal use of roosts by the Australian Pelican (Marchant and Higgins 1990). In the present study, it was found to have a similar diurnal abundance pattern to the cormorants, with peak numbers at Pond Nine at both ends of the day. In contrast, the Great White Pelican *Pelecanus onocrotalus* and the Pink-backed Pelican *Pelecanus rufescens* have been reported to forage most intensively around sunrise and sunset (Fasola and Canova 1993; Ntiamoa-Baidu *et al.* 1998). The limited data set from the night time observations in the present study suggests that Australian Pelicans might leave the roost, presumably to feed, during the night. This species has previously been reported to feed at night (Stone 1913), although it is generally considered to feed mostly during the day (Marchant and Higgins 1990). Night feeding also has been demonstrated for Great White Pelican (Ntiamoa-Baidu *et al.* 1998) and Pink-backed Pelican (Fasola and Canova 1993).

Of all the species demonstrating crepuscular peaks in abundance, the difference between the sunrise and sunset peaks was substantially greatest for the Silver Gull. However, these data may not provide a true reflection of the diurnal movements of this species. Before sunrise, large roosting flocks were often observed on an area of land less than 40 metres from the north-eastern corner of Pond Nine. Presumably the birds that assembled on Pond Nine at sunset moved to this site later. These birds usually left this roost at around sunrise. Movement of Silver Gulls to a roost at sunset, and departure around sunrise, has been reported previously (Wheeler and Watson 1963).

Black-winged Stilts were generally observed more frequently in the morning and most of the birds observed at Pond Nine were seen foraging on the edge of the islands. However, Pond Nine did not appear to be the main feeding site for this species; large flocks were regularly seen feeding in a shallow wetland that abuts the north-eastern corner of Pond Nine (commonly known as 'Paradise Ponds').

Conclusion

Large numbers of several species of waterbirds used pond Nine as a non-breeding site. Species that tended to feed away from Pond Nine demonstrated crepuscular peaks of abundance at Pond Nine, whereas species that used the pond as a feeding site were found there in consistent numbers throughout the day.

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